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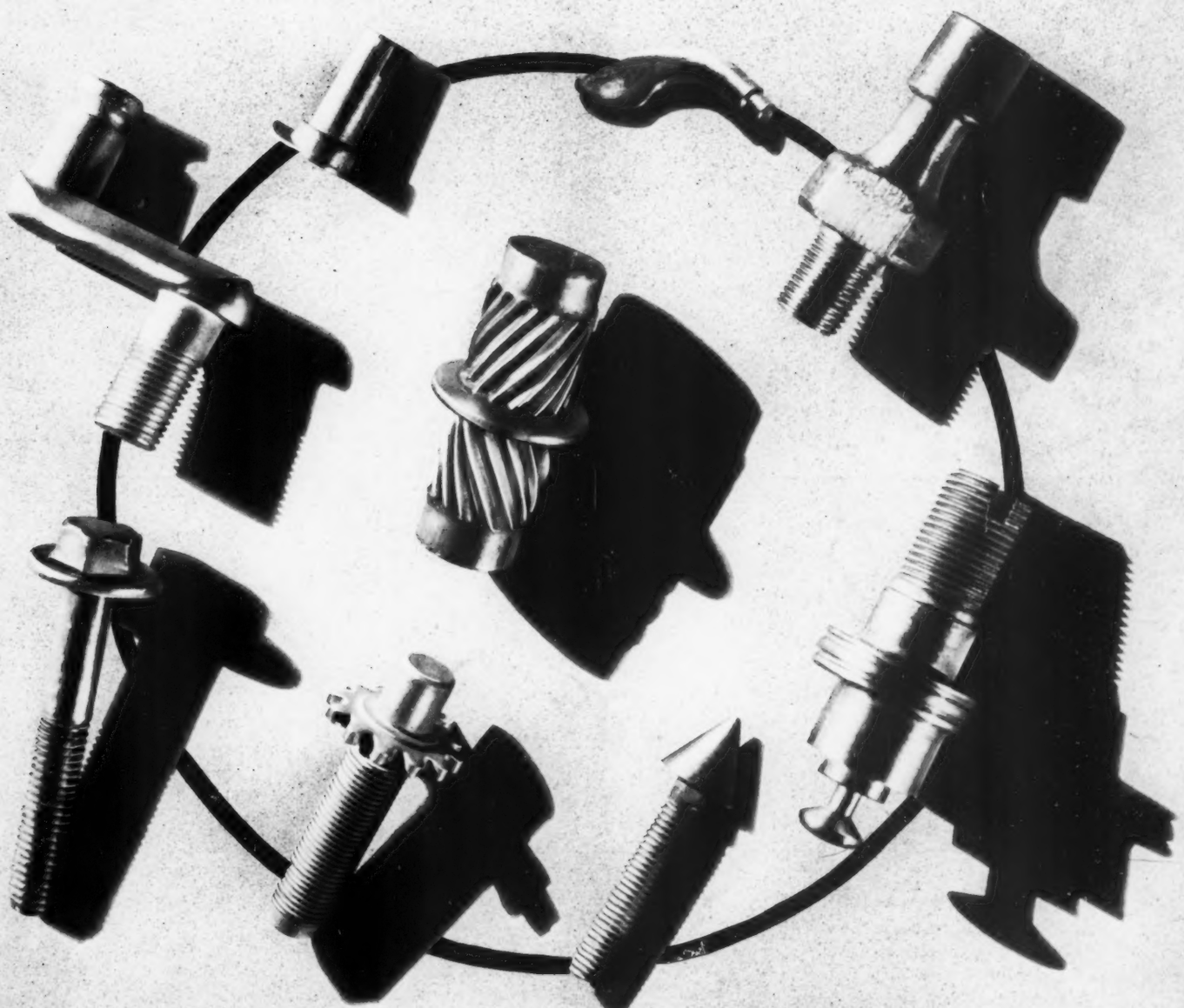

Design Possibilities in Cold Forged Parts

Design OF MACHINERY *and* EQUIPMENT . . . METHODS · MATERIALS · PARTS

ALLOY NICKEL STEELS

Boost the PAYLOAD ... and CUT HAULAGE COSTS

40 TONS PER TRIP

Typical of the tremendous capacities that are being developed through the use of the Nickel alloy steels, are these trailer units which handle 40 tons of coal per trip in an Illinois strip mine. By employing strong, tough Nickel alloy steels, the manufacturer, Austin-Western Road Machinery Co. of Aurora, Ill., was able to develop giant trailers which have substantially reduced haulage costs. Weight of parts was materially reduced, without decreasing safety factor or dependability. Nickel alloy steels were used for the rear axles, spring shackle bolts, spring shackle shaft, spring clips, wheel studs, brake drum bolts, air cylinder valve stem, cross head and pivots.

WEIGHT REDUCED 25%–30%

Another striking example of high pay load capacities which the Nickel alloy steels make possible is this semi-trailer which carries a 20-ton load concentrated over a length of only 8 feet. The high strength-weight ratio of the Nickel alloy steels effected a saving of 25-30% in the weight of the frame as well as substantial weight savings in other highly stressed applications. Producer of this unit is Utility Trailer Manufacturing Co. of Los Angeles, using Nickel alloy steels obtained from Bethlehem Steel Co.

We invite consultation on the use of the Nickel alloy steels in your equipment.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

PRODUCT ENGINEERING

VOLUME 10 NUMBER 1

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What's Coming

As a follow-up of C. W. Blount's article on molded plastics which appeared in the December number, in this issue we are presenting two pages of designs for molded plastic inserts. In our February number we are continuing on the subject of plastics with a staff article setting forth the developments in plastic applications in the automobile industry.

It has been some time since we have had an article by A. C. Rasmussen, chief engineer of the Insley Manufacturing Company, and it gives us great pleasure to be able to announce that in February *P.E.* he will have a comprehensive article on the design of gear teeth for impact resistance. This excellent article is based on the work of Prof. Earl Buckingham and shows the designer how to apply the principles developed by Buckingham.

In December we had an article and two reference book sheets on magnet coil design by G. L. Moses of Westinghouse. February *P.E.* will include two more reference book sheets on this same subject by the same author. Other feature articles in February will include one on finishes by Dr. C. B. F. Young, and the concluding installment of the Lloyd and Thomas article on motor design.

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CONTENTS for JANUARY 1939

COLD-FORGED PARTS 2
HERBERT CHASE—Typical cold-forged pieces and economies which are inherent in the cold heading process of forming parts.

MACHINABILITY OF STEELS 12
J. SORENSON and W. GATES—Selecting steels on the basis of machining costs and ratings based on relative speed of removing metal.

SPOT WELDED JOINTS 15
L. H. FROST—Designing spot welded joints in various metals with data and tabulations for quick reference.

INDUCTION MOTORS FOR MACHINE DRIVES—I 19
T. C. LLOYD and W. A. THOMAS—Analysis of the problems encountered in the selection of motor drives for rapid-reversing machines.

HEAVY-DUTY BEARINGS 22
L. M. TICHVINSKY—Characteristics of materials used for heavy-duty service, discussion of lubrication and friction.

IMPROVING PRODUCTS THROUGH RESEARCH 24
S. KEILIEN—Apparatus and tests for maintaining standards of performance and safety in wiring devices.

DESIGN OF INSERTS FOR MOLDED PLASTICS PARTS 28
F. W. WARNER and R. R. MACKENZIE—Methods for anchoring pins, sheet metal parts and formed pieces in molded plastic products.

NETWORK NOMOGRAM CONSTRUCTION 41
CARL P. NACHOD—Method of constructing a network nomogram in which a single secant solves an equation of four variables.

Editorial 1
Question and Comment 30
News 33
Meetings 34
New Materials and Parts 36
Manufacturers' Publications 40

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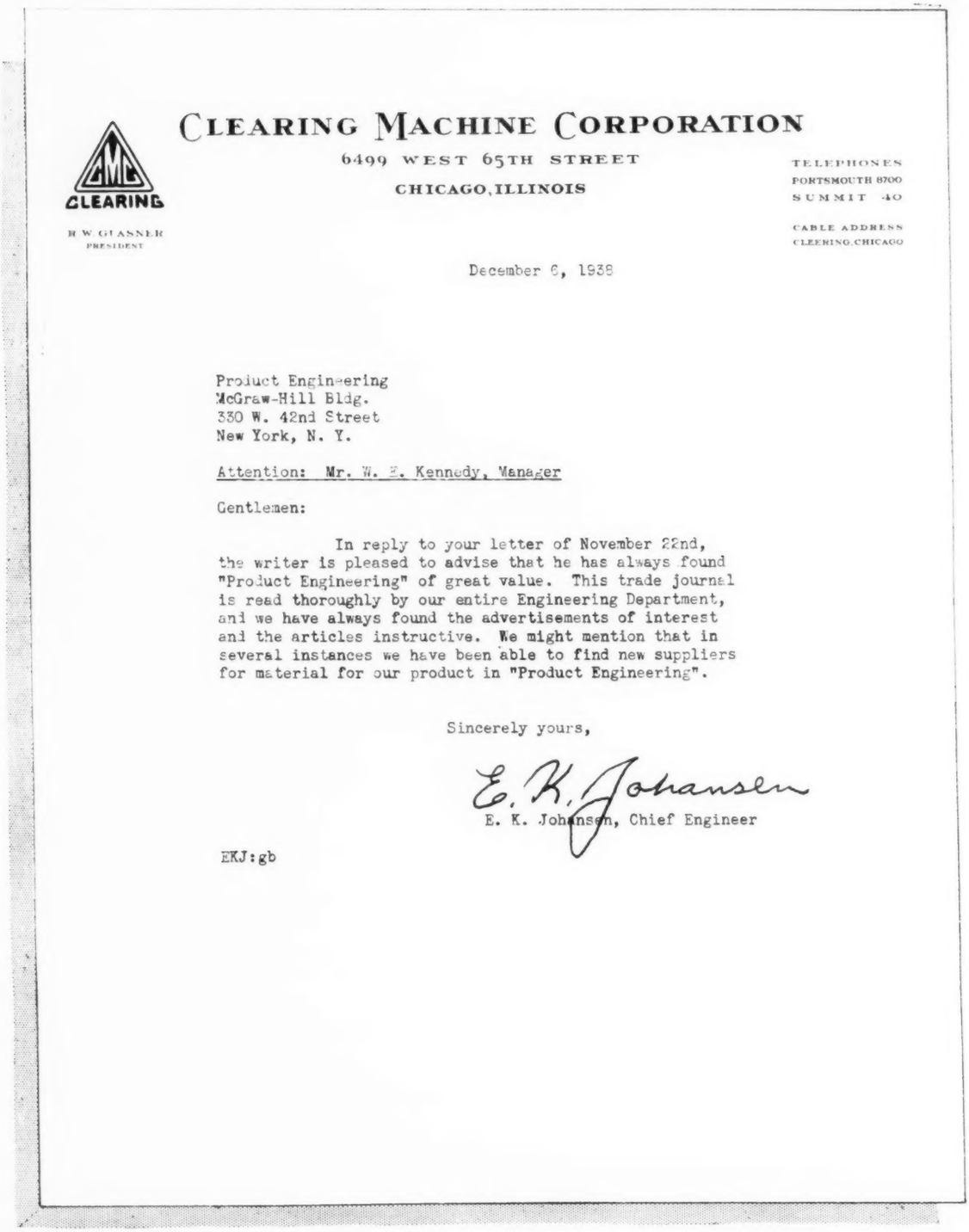

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December 6, 1938

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Attention: Mr. W. E. Kennedy, Manager

Gentlemen:

In reply to your letter of November 22nd, the writer is pleased to advise that he has always found "Product Engineering" of great value. This trade journal is read thoroughly by our entire Engineering Department, and we have always found the advertisements of interest and the articles instructive. We might mention that in several instances we have been able to find new suppliers for material for our product in "Product Engineering".

Sincerely yours,

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GEORGE F. NORDENHOLT, *EDITOR*

McGRAW-HILL PUBLISHING CO., INC. JANUARY, 1939 VOLUME TEN, NUMBER ONE

Patent Changes Inevitable

FROM THE TESTIMONY given before the Temporary National Economic Committee, one can draw any number of conflicting conclusions. Knudsen and Kettering of General Motors and Edsel Ford all testified that their industry, barring possible revolutionary developments, has passed the stage where the patent law and patents are of vital significance. In fact, with few exceptions, automobile manufacturers freely exchange patents. Packard does not, but Alvan Macauley, president, voluntarily conceded that Ford's policy of giving free licenses to all who want to use its patents, is best. Knudsen even went so far as to state that electric refrigeration and oil heating would have developed faster under a free-use of patents agreement.

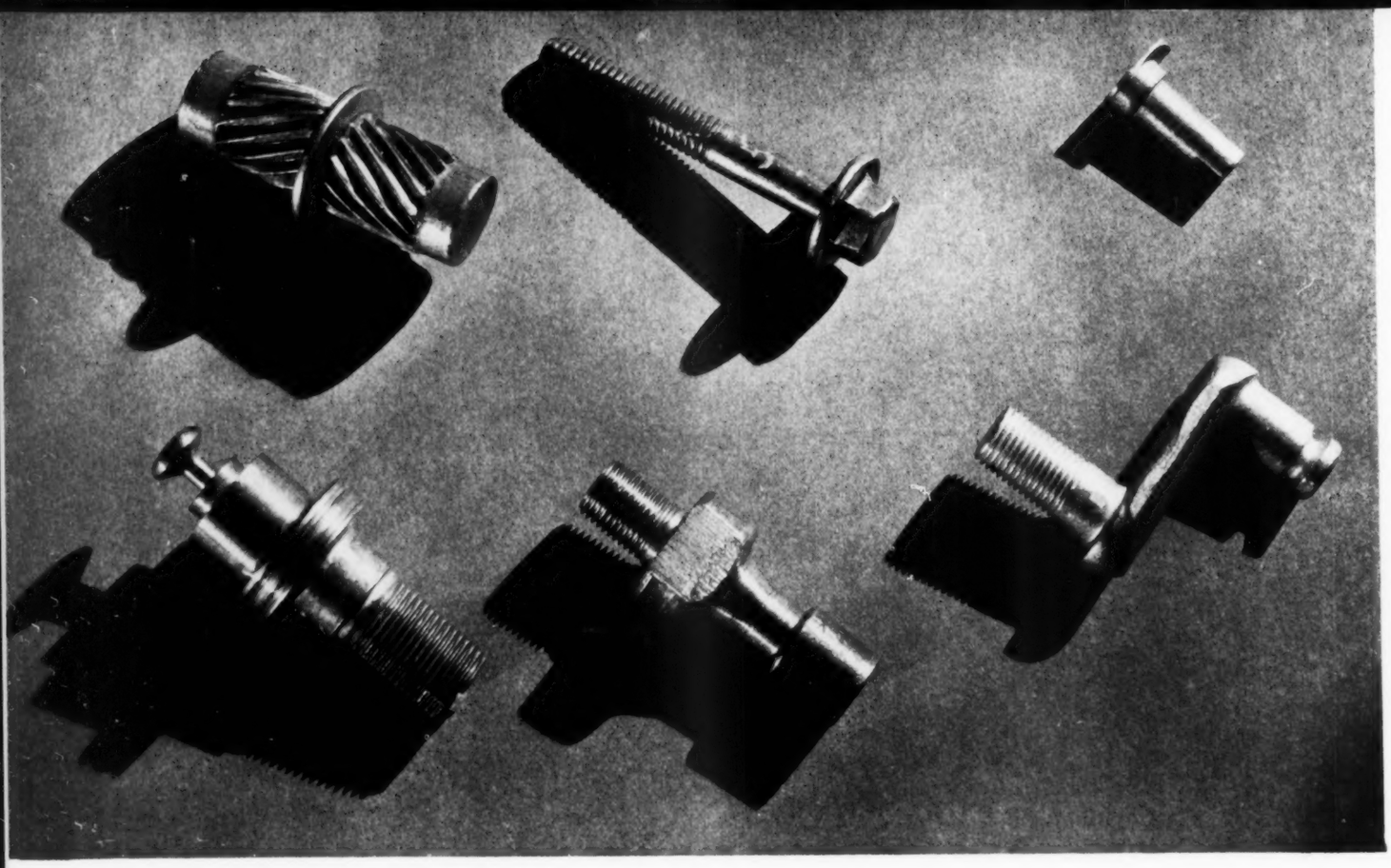
One must conclude that at least insofar as these industries are concerned the patent system serves no appreciably useful purpose and hampers progress. The danger is that sweeping conclusions might be drawn from this one example.

There are two general classes of inventions—basic inventions and those that are not basic. The latter are primarily modified aggregations, new arrangements of existing mechanisms and linkages. Fundamentally, they are new ideas to which existing knowledge is applied to yield a new device or mechanism. In the design of the present automobile, it would be extremely difficult to find one item which at the time of its initial application to the automobile, was not "old stuff" insofar as basic engineering was concerned. Selden lost his patent suit because it was proved that all he had done was to put an existing engine in an existing carriage or vehicle, connected them, and thus had an automobile.

Such design patents have little more than nuisance value and serve primarily as a means for exacting royalty. They are impediments to progress.

To some extent, the history of patents in the radio industry parallels the experiences of the automobile industry. Because of the many variable factors inherent in an electronic circuit it is possible to procure a practically unlimited number of circuits and combinations, and apparently all of them are patentable. Of these multitudinous patents R.C.A. has control of about 4,000 under which the radio industry operates paying only a single license fee to R.C.A. instead of to the many original patent holders, thus effecting a saving which would normally be paid by the purchaser.

Any decisions regarding changes in patent law must take into consideration the difference between basic inventions and those of the other type. It will take a Solomon to do it. And in addition, the Patent Office would have to be staffed with enough properly qualified and experienced men to pass better judgment on the patentability of a new device. But whatever changes may be made, they must not destroy the incentive to invent.



COLD-FORGED PARTS

Shapes and Economies That Are Possible

HERBERT CHASE

Typical pieces made in upsetting or cold forging machines with a discussion of the design advantages and economies which are inherent in the cold heading process of forming parts

EVERY DESIGNER of metal products is or should be well aware of the manufacturing economies that can be realized by use of the stamping press, the screw machine and the die-casting machine. Unless he has had experience with cold-forged parts, however, he may easily overlook economies and advantages which are often considerable for certain classes of parts that can be produced in cold-heading machines from rod stock.

Cold-heading or upsetting is only one of the operations which can be performed in the modern cold-heading machine. These machines can also perform (1) extrusion operations which reduce rather than upset or enlarge the diameter of the piece; (2) trimming operations; and sometimes (3) roll-threading operations. Besides these operations, the header feeds and shears to length the work stock, which is usually round wire or round rod. Often the machine is fitted with two or three dies with automatic means for shifting the work progressively from cavity to cavity and for discharging the work as a finished product. As the machines require very little attention, once they are set up and ready to run, labor costs are low. The rate of production is often many times that for a screw machine.

Although the screw machine and the cold header can sometimes be used for producing the same part, each machine can perform operations not possible on the other and often one supplements the other. The screw machine, however, is a cutting machine whereas the cold-header is a forging machine. The screw machine, in general, wastes a considerable part of the stock and never increases the diameter of the stock, whereas the cold-header seldom wastes more than 4 or 5 per cent of the stock, this waste being largely in ends and flash. As a consequence, the advantage of the cold-header increases, when compared to the screw machine, as the cost of the stock increases. It is sometimes an advantage to produce a partly finished blank on the cold-header and to finish it on the screw machine, especially where certain of the dimensions must be closer than can be held in cold forging. On the other hand, some dimensions are held within quite close limits in cold forging and the finish secured is amply smooth for many parts. Cold-headed parts are held within far closer dimensional limits than drop forgings and other hot-forged parts and, since the work is done cold, no scale is formed.

Some of these considerations may be thought to be of more interest to the production department than to the designer, but since the designer's success is often measured in terms of ability to work out a design which is producible at minimum cost, the engineer needs to keep in mind all factors which have an effect upon cost. Study of certain cold-headed parts and of the methods by which they are produced will give any engineer not familiar with the process a much better understanding of its possibilities, but if the designer aims to make use of the process, he will do well to submit a tentative design to someone well acquainted with cold-heading before completing a design predicated upon use of the process. This procedure will probably avoid specifications which cannot be followed with economy. Accompanying drawings and illustrations of parts produced by the Lamson & Sessions Company show certain dimensional limits which have proved to be feasible and which may serve as a guide in designing similar parts.

To specify dimensions with closer limits than are required or than can be held in mating parts, increases the cost without obtaining in return any worthwhile advantage or benefit.

Since production by cold heading requires a die or dies which are often suited for making only one particular part, their cost must usually be added to that for the total number of parts required in fixing total cost per piece. For this reason, it is seldom economical to consider cold heading unless many thousands of parts are needed. As this statement is not always true for screw-machine products, especially where standard cutting tools can be employed, the screw-machine product is likely to be cheaper for short runs.

As considerable plastic flow of metal

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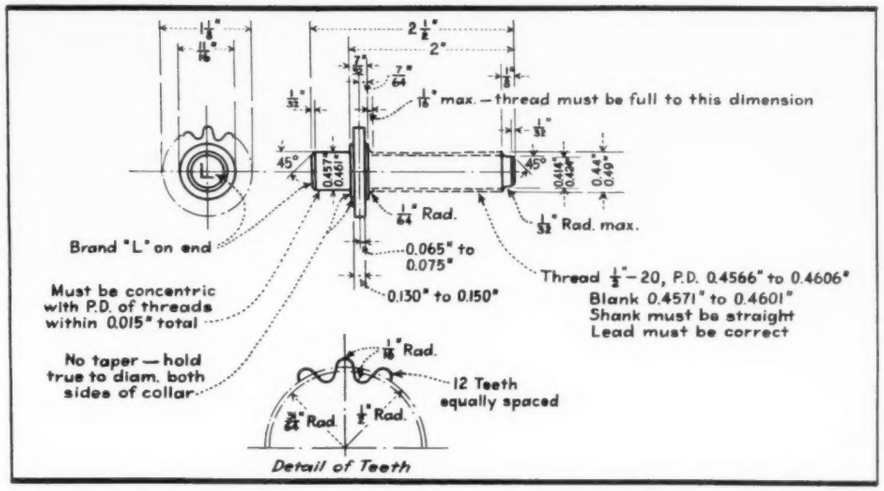
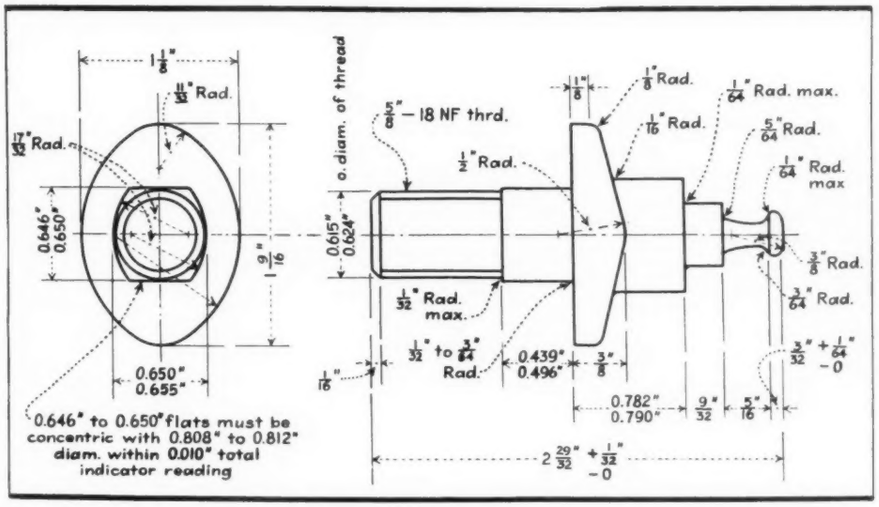
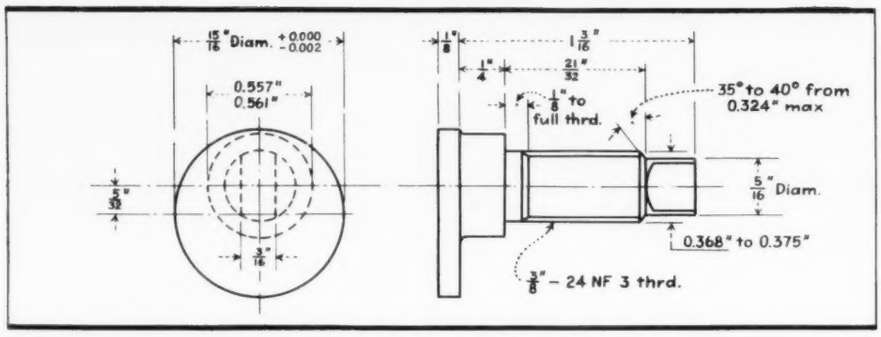


Adjusting part for automobile brake shown is produced by cold heading. This part has a flange thrown up to a diameter of 1⅛ in. about one quarter of the length from one end. The edge of the flange is given a tooth-like serration in a final trimming operation which in this instance is not done in the heading machine. A ½-in.-20-pitch thread is rolled on the longer portion of the shank. This part is cold headed from SAE 1035 coiled wire of about ½ in. diameter, the long end of the shank being extruded to the proper limits for roll threading an SAE thread. Originally, this part was produced on a screw machine, the twelve teeth being cut on an indexing fixture in another machine, the last operation. Production by cold heading with the subsequent operations named is said to have reduced cost about 75 per cent.



Cold-headed part that is somewhat unusual is a bolt with an elliptical shaped collar made by cold heading ⅝ in. SAE 1035 steel on a two-blow header. The blank is trimmed to the elliptical shape and then put on a screw machine where it is finished to the diameters indicated. The screw machine also forms the knob-like portion on the upper end. With this piece, the primary saving resulting from cold heading is in material and in the time required to produce a piece from 1½ in. stock by making heavy cuts in a screw machine. The elliptical collar, of course, would be difficult to machine.



Offset head part that is the result of ingenious engineering. It is produced by cold heading on a two-blow header from $^3/_8$ in. SAE 1035 steel received in coils. In the first operation the blank is headed with an offset, but has a small flash on the head. The second operation consists of trimming the flash from the head of the bolt. In the third operation the shank of the bolt is extruded to the proper diameter for rolling the thread to the SAE dimensions. The extruded blank is then put on a production miller where the end is slabbed as shown. After slabbing the bolt is drilled through the head. Finally the bolt is finished by being roll threaded and then heat-treated to remove the heading strains involved.

Nut-shaped parts, except for tapping, are formed complete in cold heading machines. The final operation is to punch out the central hole, the ends of the hole having been formed in the next preceding operation. In the production of pieces of this form, the slug punched out and the metal removed by the tap constitute waste, but the faces, flats and beveled edges of the nuts do not require finishing. Several other cold headed parts, more or less typical of those produced by this process are shown in the illustration at the head of this article. Bolts of various types account for a large proportion of the total output of cold-headed products, but it is evident from the foregoing that the process results in economies for a large variety of other parts and on this score may well be given consideration by designers.

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is required in cold heading, the operation is confined to materials of adequate ductility. Cold-drawn low-carbon steel is most widely used, but work is done with steels having a carbon content up to 0.50 per cent and with certain alloy steels such as SAE 2330 and SAE 3135. Various stainless steels are also suitable for cold heading some parts. Invar alloy is used for some small parts. Several non-ferrous alloys including brasses and bronzes as well as aluminum alloy are also employed to some extent, especially where corrosion resistance or light weight is important.

Although many cold-headed parts have a large proportion of their length in cylindrical sections, they frequently have heads and sections of the body that are square, hex or some odd shape which need not be symmetrical about the axis of the cylindrical section. Some parts are produced with cylindrical portions eccentric to the major axis. Also, certain crank-shape parts have been produced. Heads may be flat, beveled, rounded, embossed, depressed or otherwise shaped and if a flange is required it need not be at the end of the piece. Fairly sharp outside edges can be produced if required, but inside corners should have at least a small fillet. Shanks may be straight or tapered. Ends can be beveled or cupped. Flanged pieces with hubs can also be formed, and if desired the flange can have small projecting nibs for projection welding. In all these parts, the blank is sheared from round rod or wire and upset by flowing the metal under the impact of the punch or is extruded (reduced in diameter) by forcing the piece or a section of it into a hole in the die. If required, both extrusion and upsetting can be done in a single blow, but in many parts two or three blows per piece are struck, the piece then being shifted in the die between blows and when required finally trimmed.

Size of Work Stock

In general, cold heading is done on stock of 1 in. diam. or smaller. The length naturally varies with the size of the machine, but, at least, in the larger diameters, the maximum length usually ranges from 6 to 9 in. The maximum increase in diameter is usually $2^1/_2$ times the stock diameter for a single blow and $3^1/_2$ to 4 times for two blows.

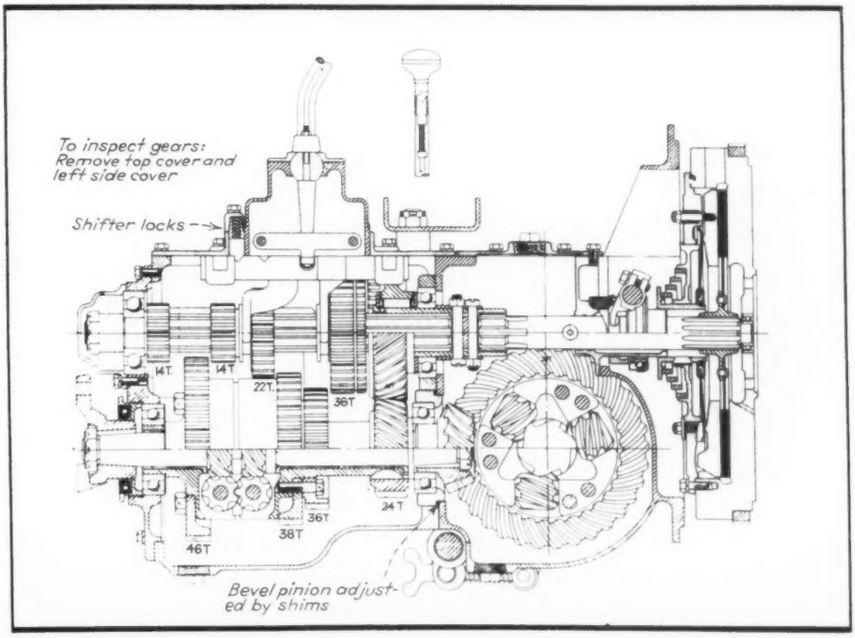
Naturally, cold working tends to harden the metal and to set up internal stresses. As a rule it is not necessary to relieve these conditions by annealing, but for some parts annealing is required and with certain exceptional shapes it is necessary between operations. The formation of scale can be avoided, however, if annealing be done in furnaces in which a reducing atmosphere is maintained—a type of equipment which is becoming increasingly common. The particular requirements of the piece, including the degree of cold working involved, the severity of stress to be encountered in service, the character of finish specified and other considerations, dictate the heat-treatment necessary. A complete heat-treatment followed by quenching in oil or water is usually required where specifications call for the maximum strength or hardness that can be developed in the material.

Modern Designs

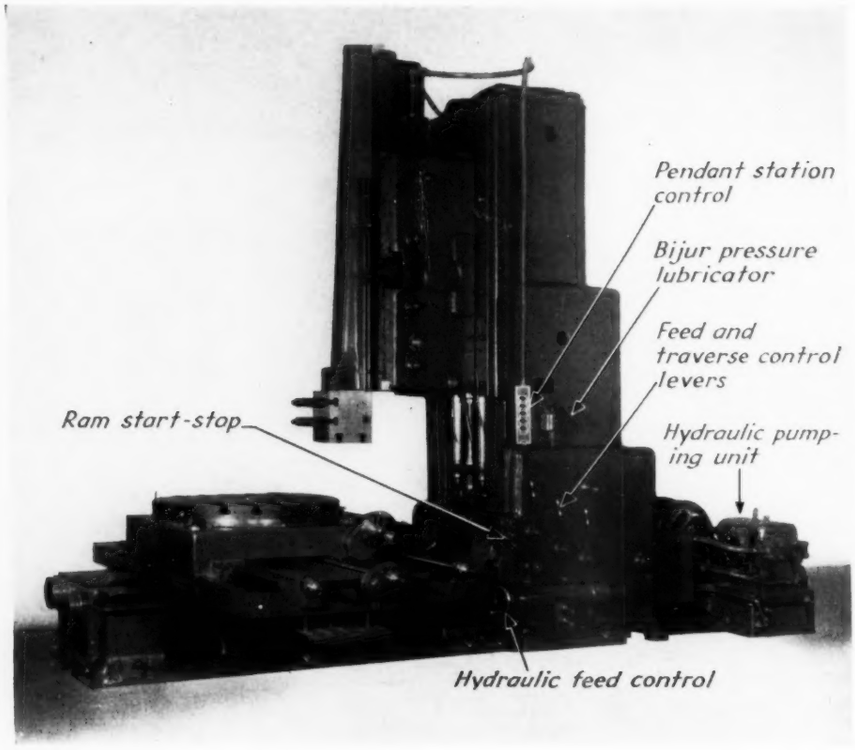
Positive-Drive Differentials on Heavy-Duty Truck

Usual automotive differentials permit one driving wheel to make more revolutions than the other in rounding a curve, but have the disadvantage that, when one driving wheel slips, the other remains fixed and the vehicle stalls. Various means of overcoming this have been devised, most of them depending on excessive moving friction at the pivots or some other point, with consequent excessive wear. Walter four-wheel drive trucks, widely used in snow removal and other work where there is poor surface traction, utilize three specially-designed differentials. One is located in the transmission dividing power between front and rear wheels; the others are in driving units supported on the frame.

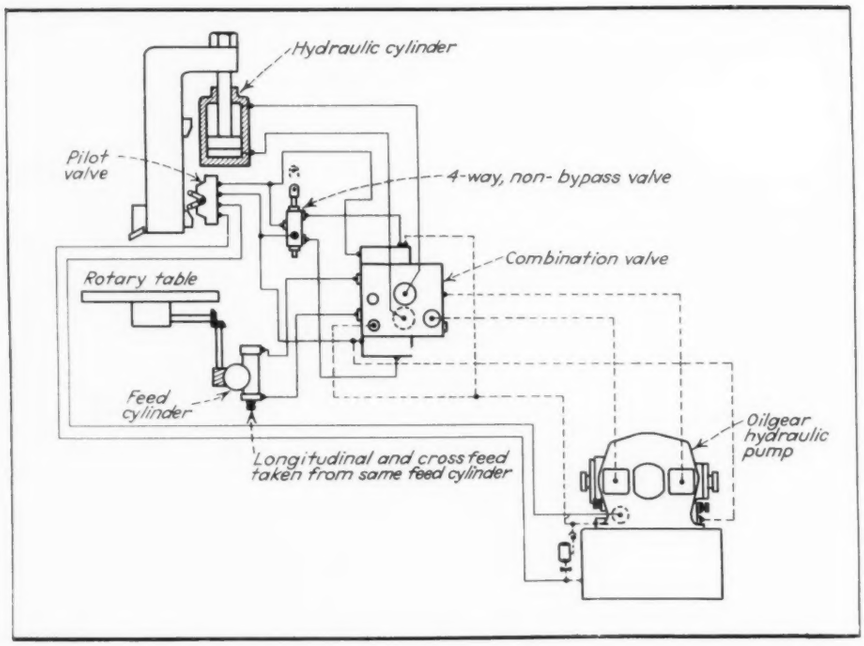
Cross-sectional view of the differential is shown at the right. Drive is positive under all conditions; all four wheels drive together, the torque delivered to each being limited to the tractive resistance. Gears and pinions of the differential are of the worm type and substantially irreversible. The differential locks when different wheels encounter varying degrees of tractive resistance; as a result, the gears do not turn or have relative motion and wear is minimized. Locking is a result of friction, but not a friction accompanied by motion. In Walter tractors for coal-stripping operations, the transmission is placed above the front axle and the engine is overhung in front. This helps to distribute the load to the wheels and tends to equalize the tractive power. Drive from the differentials to the wheels is transmitted by transverse shafts with universal joints to pinions meshing with inclosed gears in each wheel housing.



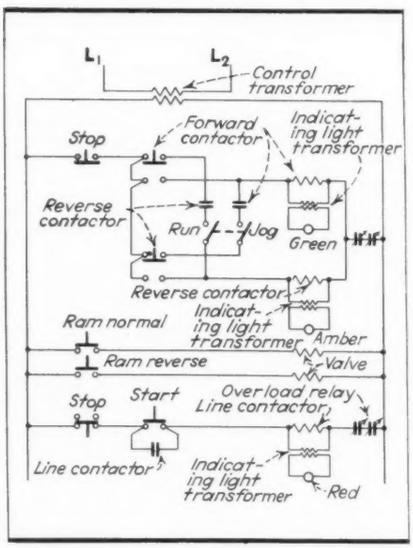
Modern Designs—Vertical Slotter Operated Hydraulically



INFINITE variation of ram speed is provided by a variable delivery pump in the Rockford Machine Tool Company's vertical slotter. Slotter is driven by a 20 hp., 1,200 r.p.m. constant speed motor driving a 20 hp. Oilgear pumping unit. Ram stroke is 38 in., table diameter is 42 in., and weight of machine is 17 tons. Ram positioning is accomplished with trip dogs set in a T-slot on the ram. Ram can be tilted to give an angular setting up to 10 deg. from vertical. A removable center plate in the table allows access to a pilot bushing in the bed which acts as a guide for a slotting bar to give extreme accuracy. Intermittent feeds and rapid traverse are provided in both transverse and longitudinal, as well as circular, directions. Bijur pressure lubrication system services all slow speed bearings; a pump and separate pressure supply is used on the ram bearings.



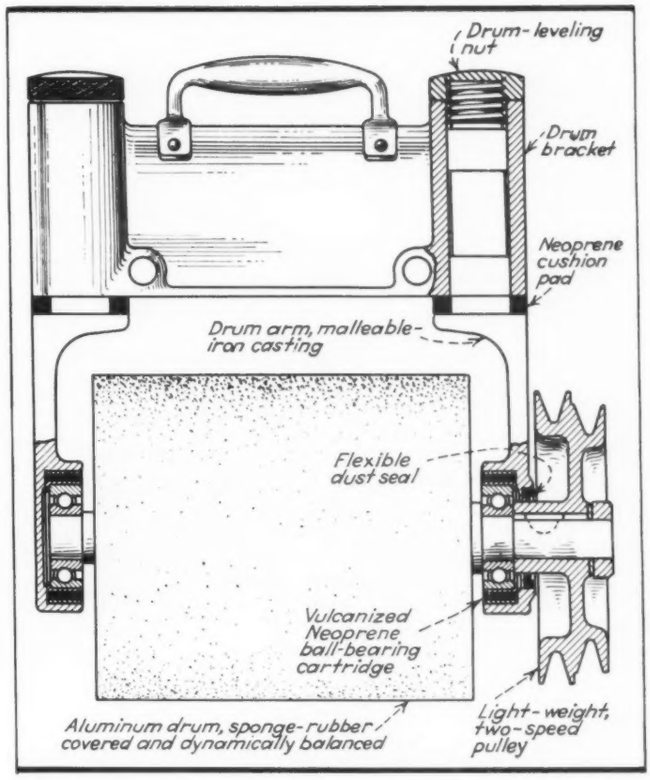
Variable-delivery Oilgear pump delivers oil under a maximum pressure of 1,100 lb. per sq. in. to a combination valve which directs the oil to and from the vertically-mounted cylinder which has its piston rod directly connected to the ram. A pilot circuit under 85 lb. per sq. in. pressure is alternately reversed by the control dogs on the ram that cause the main reversals in the ram circuit. A solenoid-operated four-way non-by-pass valve, operated from the pendant station, is connected in the pilot circuit to reverse normal flow. The feed cylinder operates hydraulically taking its power from the ram circuit for an intermittent feed at the beginning of the cutting stroke. This motion is transmitted to the table through a rack and pinion, free-wheeling clutch and bevel gears. Hydraulic pumping unit is located at rear of column, minimizing amount of piping.



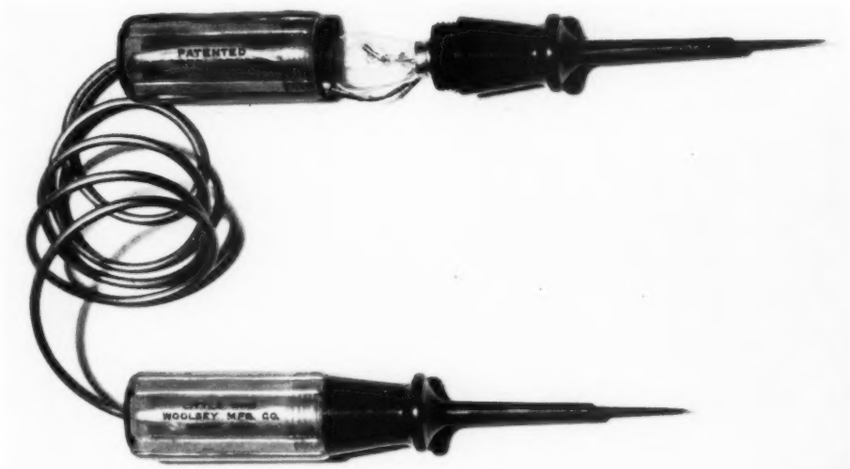
Electric circuit control is centered in the pendant station. Run or jog of the rapid traverse motor is controlled by the top selector switch, which will operate the rotary, transverse or longitudinal direction, or for raising and lowering the ram housing according to the clutch levers selected on the column. The stop button is used only when the selector switch is in the "run" position, because in the "jog" position the motor runs only as long as the second or third button is depressed. The entire control circuit in the pendant switch is stepped down from a higher main line voltage to 110 volts.

Resilient Bearing-Mountings and Nested Motor

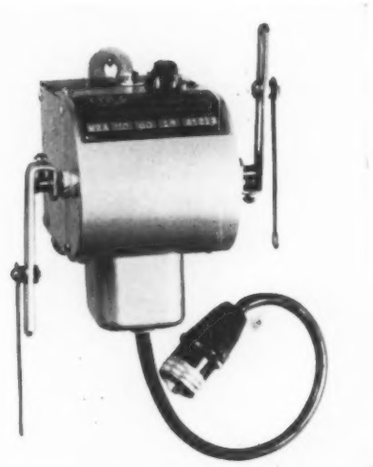
Eight-inch floor-sanding machine, designed under the supervision of A. N. Emmons, chief engineer Porter Cable Machine Company, has specially-developed cartridge units in which the drum bearings are mounted. These units consist of an inner and outer steel ring between which is inserted and vulcanized a neoprene ring. This assembly affords a flexible mounting which will support the bearing under compression or in tension, allowing the sander drum to follow the floor surface without bearing strain. The drum is dynamically balanced. Drum pressure can be adjusted for abrasive-paper wear by a handy ratchet control on the machine handle.



Cross-sectional view of sander drum mounting, showing the neoprene cartridges supporting the ball bearings. The drum arms are also mounted on neoprene to absorb vibration and eliminate chatter marks. Additional features of this sander include a method of motor mounting utilizing two pull-out pins as rear support, permitting easy removal of the motor; a throw-over switch mounted on the 1½ hp. motor for changing from 110 to 220 volts instantly; and a fulcrum pin, of hardened steel, mounted on needle bearings. Chassis and drum arms are of malleable iron. Guards, frame and motor housing are aluminum alloy, highly polished. Drum is sponge-rubber covered.

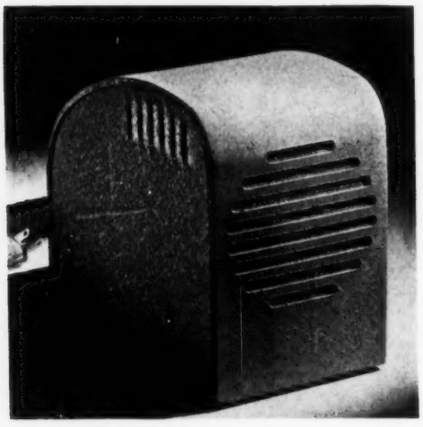


"Little Bob" circuit tester for locating grounds and shorts is injection-molded of cellulose acetate by the Detroit Paper Products Company, the hardened sharp-pointed blade being used as an insert. The shank is molded with recess at its inner end to accommodate a miniature lamp socket and lamp.

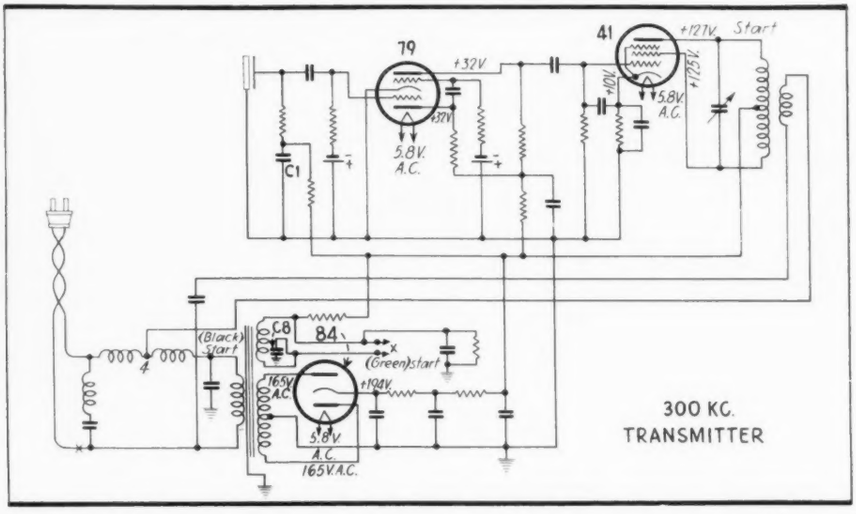


The Friez damper motor is governed directly by the control instrument without recourse to relays. Motor has three position auxiliary hand switch.

Modern Designs—Super-Sensitive Sound Amplifying System

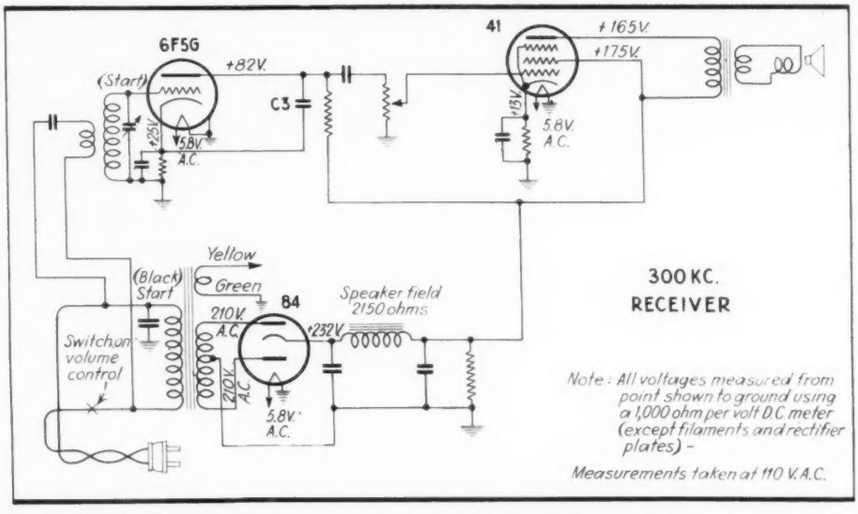


Zenith Radio Nurse, a compact sensitive sound amplifying system for use in nurseries and sickrooms, conducts the generated signal through the home lighting circuit to the receiver.



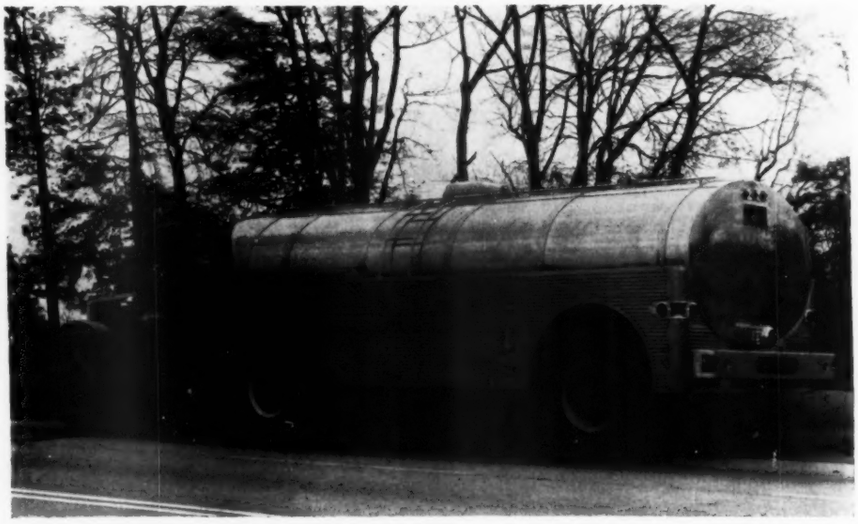
The pick-up unit contains a condenser type microphone, speech amplifier and modulator-oscillator circuit, housed in an ivory-finished plastic case.

The receiving unit is housed in a mottled walnut plastic case. Both housings are molded of Bakelite by Kurtz-Kasch Company and the Chicago Molded Products Corporation.



Receiving circuit consists of a detector tube, an audio amplifier and reproducer. Total amplification from microphone to speaker is 500,000 times.

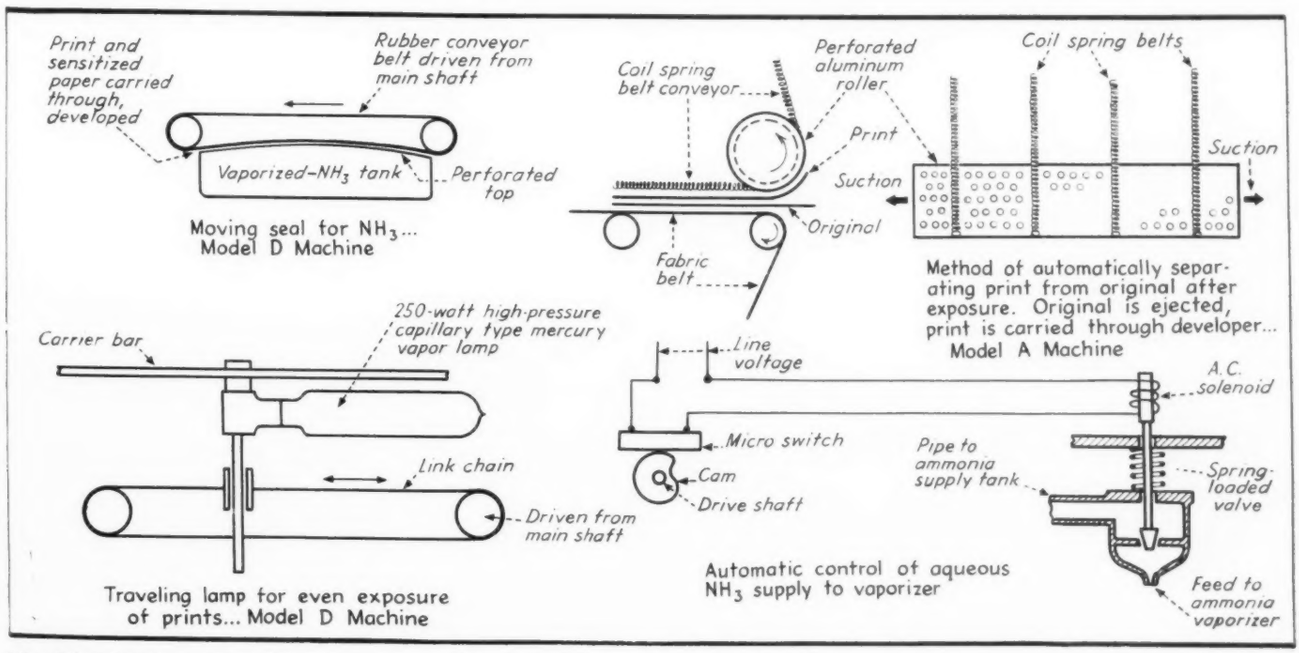
Chassis on this new tank trailer is fabricated in the form of an outside skirting with deep bulkheads extending from side to side for tank support. Considerable weight saving has been realized because the chassis is located where a skirting is ordinarily used on conventional equipment. By placing the structural material at this point, greater beam depth is possible, thereby increasing the stiffness of the structure over conventional frame design. Chassis is built up of stainless steel by the Edward G. Budd Manufacturing Company. The trailer weighs 9,100 lb., yet has a maximum axle loading of 22,400 lb. Tank for the unit is fabricated by the Standard Steel Works and consists of a stainless steel interior shell with an aluminum exterior shell. Unit is powered by a Mack tractor.



Higher-Speed, Modernized Dry Process Printer

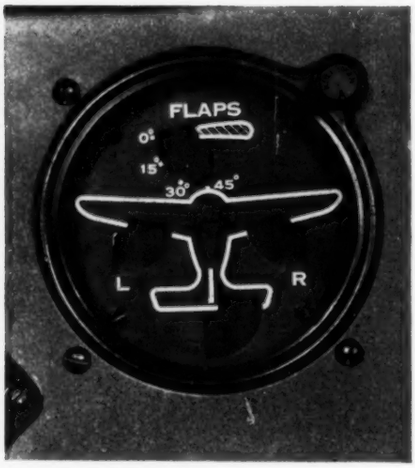
The new Ozalid dry printing machines combine the printer and developer in one unit. The machines incorporate automatic controls to assure uniform exposure, quick printing speed and ease of handling. The white line prints are produced in two operations without the aid of a negative. Prints are true to scale since no liquids, which might cause shrinkage, are used.

In operation, the original and the sensitized paper are exposed to the highly actinic ultra-violet light produced by the 250-watt high pressure mercury vapor lamp. This light disintegrates the coating, except where it is protected by opaque lines; the remaining coating reacts with dry ammonia fumes to produce the lines on the print.

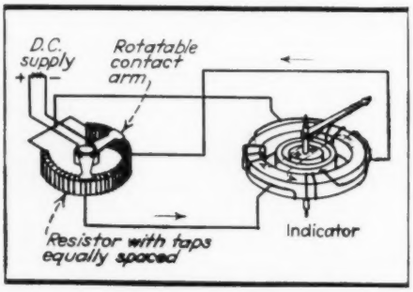

Print and sensitized paper carried through, developed
Rubber conveyor belt driven from main shaft
Vaporized-NH3 tank
Perforated top
Moving seal for NH3... Model D Machine
Coil spring belt conveyor
Perforated aluminum roller
Print
Suction
Original
Fabric belt
Coil spring belts
Suction
Method of automatically separating print from original after exposure. Original is ejected, print is carried through developer... Model A Machine
Carrier bar
250-watt high-pressure capillary type mercury vapor lamp
Link chain
Driven from main shaft
Traveling lamp for even exposure of prints... Model D Machine
Line voltage
A.C. solenoid
Micro switch
Cam
Drive shaft
Pipe to ammonia supply tank
Spring-loaded valve
Automatic control of aqueous NH3 supply to vaporizer
Feed to ammonia vaporizer

Machine features are shown diagrammatically above. In the large Model A, separation of the tracing from the print after exposure is accomplished by suction through holes in a roller of 3S aluminum. The print is carried through the developer on the coil spring belts. Variable-speed drive permits selection for proper exposure. Automatic electrically-controlled drip feed for the acqua ammonia is included in the developer unit. In the smaller Model D, a traveling lamp assures even exposure of the print. The movement of the lamp is synchronized, by means of a link chain, with the driving mechanism. A rubber conveyor carries the print over the ammonia tank, and also serves as a seal.

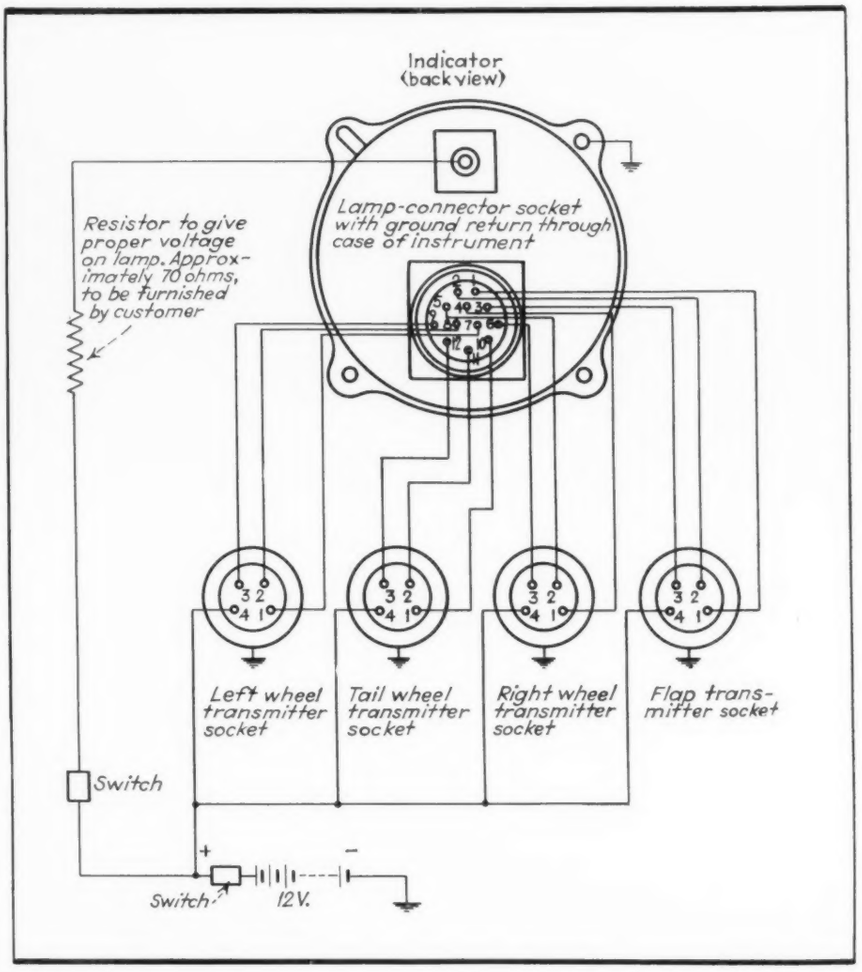
Modern Designs—Selsyn Motors on Airplane Instruments



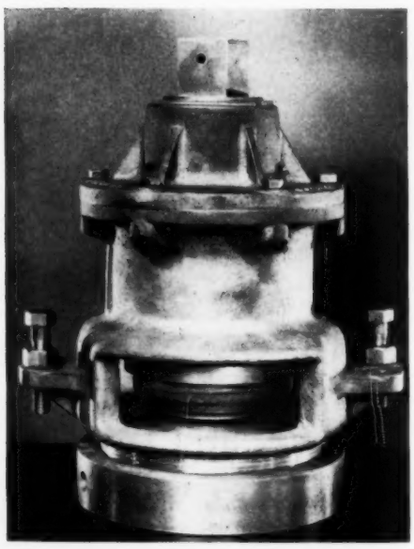
Positive indication of the positions of wing flaps and retractable landing gear relative to the plane structure is provided in a new line of airplane instruments operated by the newly developed General Electric d.c. Selsyns.



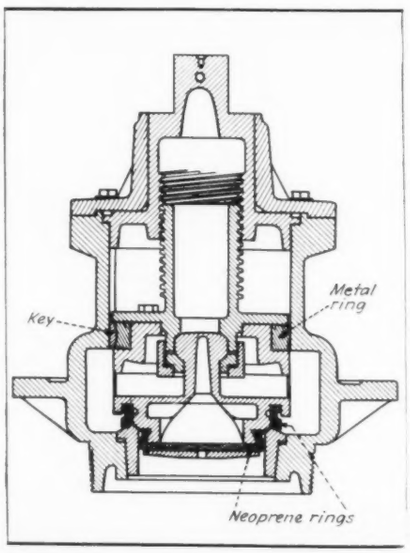
Transmitter consists of a tapped resistance winding to which power is supplied by rotating arms. The resistor taps connect to an indicator ring made up of ferromagnetic laminations around which are wound three coils.

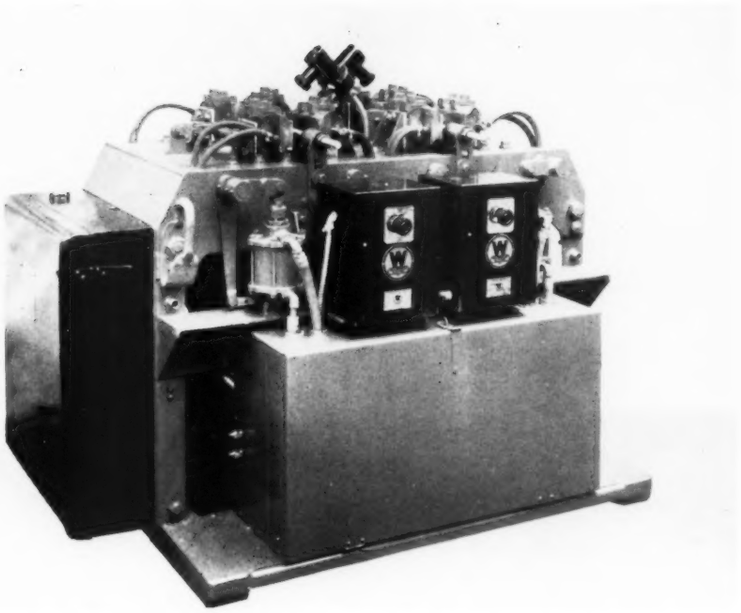

Indicator (back view)
Resistor to give proper voltage on lamp. Approximately 70 ohms, to be furnished by customer
Lamp-connector socket with ground return through case of instrument
Left wheel transmitter socket
Tail wheel transmitter socket
Right wheel transmitter socket
Flap transmitter socket
Switch
Switch
12 V.
+
−

Division of voltage around the transmitter resistor sets up a magnetic flux diametrically across the indicator ring, the position of this flux being in constant relationship to the position of the transmitter arms. A polarized, permanent magnet rotor on the indicator shaft aligns itself with the flux, indicating the transmitter arm position. Transmitter arms are rotated by bell-crank and linkage connected to the gear- and flap-operating mechanisms on the structure.



Difficulties caused by corrosion, scale, or other foreign matter on the valve seat have been minimized in this newly designed George tank car valve by the use of neoprene rings which seal the face of the valve while it is open and provide a wiping action which cleans the seat of scale when the valve is closed. The neoprene rings surround the face of the valve disk when in the open position. As the valve moves downward, the shoulder of the valve contacts the rings at their junction point, separating them and causing the upper ring to move outwardly. This movement cleans the shoulder of scale. Simultaneously, the lower ring moves across the valve seat wiping the scale and foreign matter, thus presenting a clean surface to the valve face previously protected by the envelopment of the rings. Valve is of bronze.

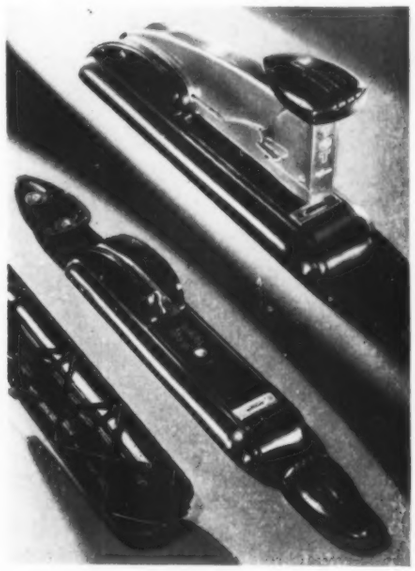




A.C.F. electric heater can be used on both steel and non-ferrous metal stock ranging from ¼ in. to 1½ in. diameter, and from one to twenty-three in. in length. Two photoelectric eyes provide automatic temperature control between 1,100 deg. and 2,300 deg. F. Air cylinders lock the stock in position.

Redesigned, the National Carbide lamp has a molded rubber handle which protects the user if the lamp frame should contact a third rail or live wire. Rear reflector is molded plastic. Lantern frame is of polished brass.

Hydraulic lift truck, built by West End Equipment Corporation, has the hydraulic cylinder recessed in a horizontal position in the frame of the truck, protected from lateral and vertical shocks. Truck has an all-welded steel frame. Axles are of alloy steel; front turntable is supported on ball bearings.



Reinforcing ribs molded into the underside of the base add rigidity, allow the use of relatively thin walls and minimize amount of material required in the Parrot Speed Fastener, injection molded of Tenite by the American Insulator Corporation. The base and cap are riveted to the metal parts of the fastener.

Random Jottings About New Developments

Utilizing a permanent magnet made of Alnico, a tiny motor has been developed for model locomotives by Gordon Varney. Compact motor is only 2½ in. long and weighs 2½ oz. It develops 1/100 hp. on 1½ amperes. High coercive force and permanence of magnets made from this alloy makes it suitable for compact designs where small size, combined with high power, is essential.

* * *

One-piece seamless drawn stainless steel tubs are fabricated by Geuder, Paeschke & Frey Company for Speed Queen electric washers.

* * *

New Portadesk looks and carries like a suitcase when closed; and provides a desk 24 x 19 in. when open.

MACHINABILITY OF STEELS

Ratings Based on Relative Speed of Removing Metal

JAMES SORENSON, *Chief Metallurgist*
and
WALLACE GATES, *Head of Standards Department*
The Four Wheel Drive Auto Company

OFTEN THE SELECTION of steels is not so dependent on their physical properties as it is on the amount of time and money which will be spent in machining them. When any one of several steels can be used because they are similar in physical properties, usually the one that has the lowest original cost is selected. Yet, it may be so difficult to machine that the finished part will cost much more. For that reason we have been determining the relative machining speeds of steels.

We began by making up standard test pieces from several different material specifications on which the physical characteristics, chemical specifications, and structural composition were definitely known, and proceeded to obtain relative machinability values. These were compared with other steels of similar physical and structural characteristics and by means of interpolation, machinability values were obtained which were somewhat theoretical. However, these values were drawn up in the form of a table after which the ratings in the table were checked according to our actual shop operations.

During this procedure of checking the machinability values against shop operations a close study was made of all the conditions which might influence the results, and in that way all variable factors such as tool shapes, types of machines, operators and other factors were averaged out. In other words, when we knew what volume of metal was removed from a certain part made of a certain material in a certain time, the machinability of that metal was determined as far as our own shop practices were concerned.

With the mass of data on our own production rates for all kinds of materials on all sizes of parts for many kinds of machine operations, the values given in the tables for hot and cold rolled steels were established. Of course, these are not necessarily absolute, but do show what can be done with the best methods and shop practices available to us. All of these ratings were determined on the basis of volume of material removed in any given time. Three variables are involved; surface speed, depth of cut and rate of feed. The tools or the material generally determine the depth of cut, so that the remaining factors, feeds and surface speed, determine the volume of metal removed on any operation per unit of time.

It might be argued that conditions in another shop would make such ratings useless. But all of these ratings are only relative, having been established with reference to the rate at which SAE 1112 can be machined in our shop. Differences in practice which change the rate of removing a given volume of metal should require only a shift in the base line, but no appreciable change in the relative machinability of the material.

The combination tables and charts provide data on machinability of more than 100 steels having various ultimate tensile values and various Brinell hardness values. It is admitted that information on this subject could be added to indefinitely with every change in material and heat-treatment.

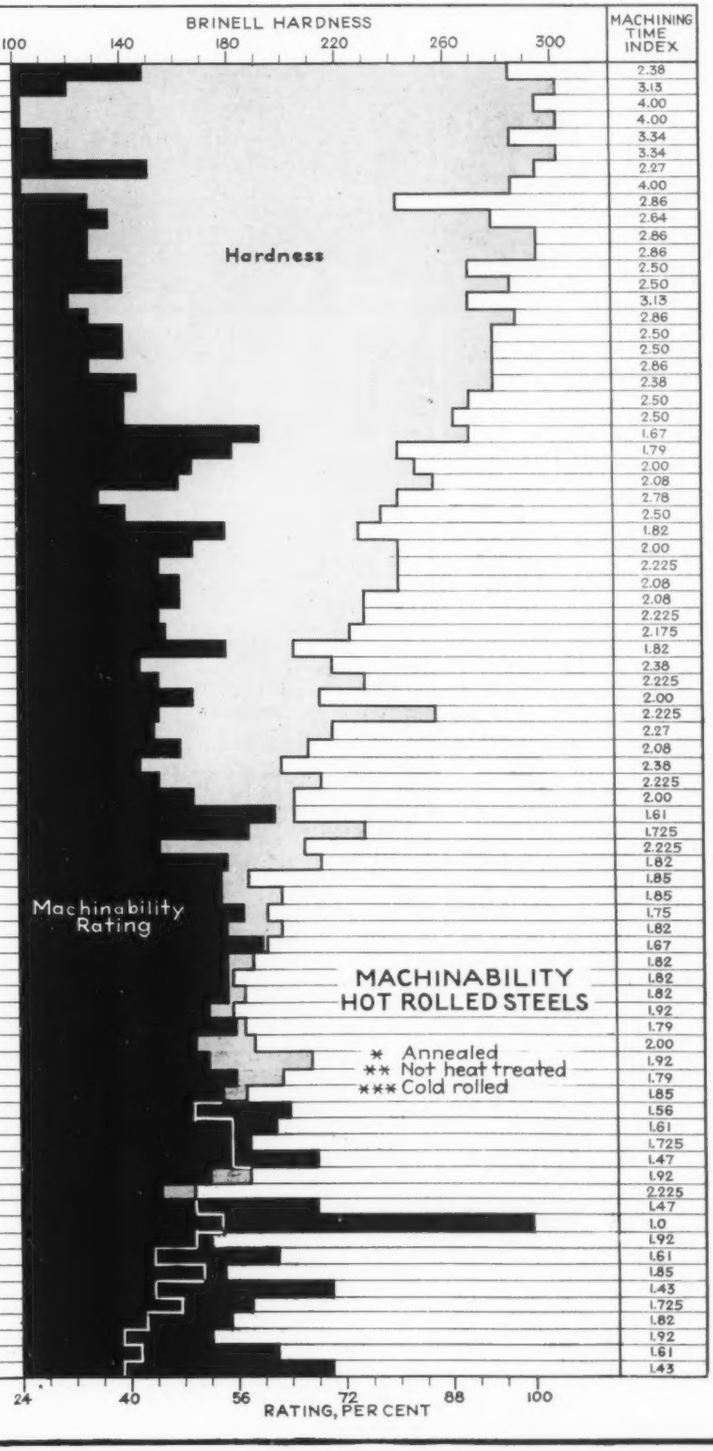
Upon casual inspection of the chart it will be noted that increase in machinability usually accompanies decrease in hardness and tensile value. While this is true to some extent it will be noted that in certain specific instances there are wide divergencies from the general statement so that care must be exercised in drawing any such conclusion at this time. This will be borne out by examination of any of the given classifications of SAE steel wherein there may be wide variations in machinability.

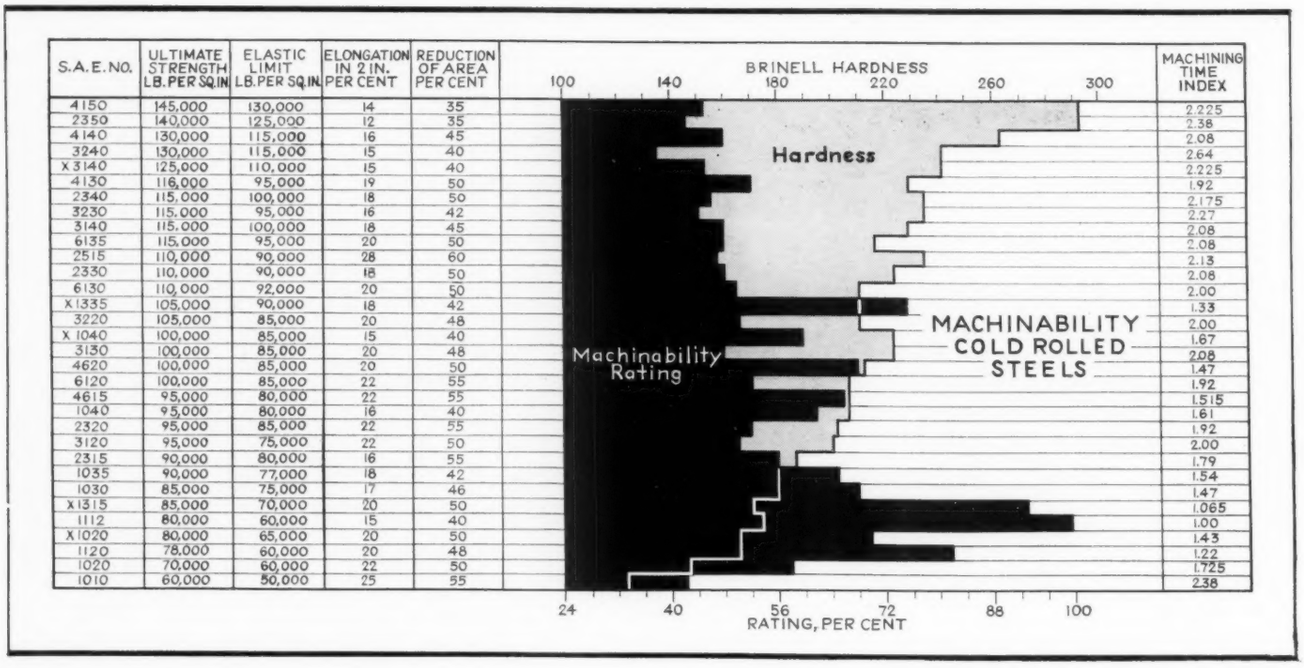
To indicate more specifically what a machinability rating means to the designer, a machining time index was added to the tables. This index shows, for example, that SAE 2350 or 3340, having an ultimate tensile strength of 150,000 lb. per sq. in., will take approximately four times as long to machine a given volume from the raw stock than it would if the piece were made of SAE 1112. All other steels have ratios varying from 1.43 up to 4, as shown in the table.

Let us assume that we are designing a part that will require a simple turning operation on a bar weighing 10 lb. Let us also assume that we want to use a material having 100,000 lb. per sq. in. ultimate tensile strength.

From the table we pick out those steels that have the desired ultimate ten-

S.A.E. NO.	ULTIMATE STRENGTH LB. PER SQ. IN.	ELASTIC LIMIT LB. PER SQ. IN.	ELONGATION IN 2 IN. PER CENT	REDUCTION OF AREA PER CENT	MACHINING TIME INDEX
4340	150,000	125,000	22	56	2.38
4150	150,000	125,000	18	45	3.13
3340	150,000	125,000	20	54	4.00
2350	150,000	125,000	16	42	4.00
3250	145,000	120,000	16	48	3.34
2340	145,000	120,000	18	50	3.34
4640	142,000	125,000	21	60	2.27
6150**	140,000	105,000	16	42	4.00
3340**	140,000	100,000	20	50	2.86
3140	140,000	115,000	18	48	2.64
2330	140,000	110,000	18	50	2.86
6135	138,000	120,000	20	52	2.86
5140	135,000	115,000	20	50	2.50
4140	135,000	122,000	18	55	2.50
3240	135,000	115,000	18	50	3.13
6130	130,000	115,000	20	55	2.86
4130	130,000	115,000	20	55	2.50
3312	130,000	110,000	22	58	2.50
3230	130,000	105,000	18	50	2.86
6140**	125,000	110,000	15	40	2.38
3220	125,000	95,000	18	45	2.50
3130	125,000	105,000	20	50	2.50
X1335	125,000	100,000	18	45	1.67
4640**	120,000	90,000	12	40	1.79
4620	120,000	90,000	20	58	2.00
3312**	120,000	90,000	22	55	2.08
3250**	120,000	95,000	18	45	2.78
9260*	115,000	82,000	18	42	2.50
4820	115,000	75,000	20	50	1.82
4615	115,000	88,000	20	60	2.00
3120	115,000	90,000	19	60	2.225
2320	115,000	88,000	20	55	2.08
2315	110,000	84,000	22	60	2.08
9255*	110,000	80,000	20	44	2.225
5140**	110,000	85,000	20	50	2.175
4815	110,000	80,000	20	50	1.82
3340*	110,000	90,000	22	58	2.38
2515	110,000	68,000	30	65	2.225
2350*	110,000	80,000	22	45	2.00
1040	110,000	90,000	18	45	2.225
3250*	108,000	80,000	22	50	2.27
6150*	105,000	75,000	24	50	2.08
3450	105,000	75,000	22	52	2.38
3240*	105,000	75,000	24	50	2.225
6140*	100,000	70,000	25	55	2.00
4640*	100,000	85,000	18	45	1.61
4340*	100,000	80,000	25	60	1.725
1095*	100,000	60,000	22	45	2.225
1035	100,000	70,000	24	55	1.82
6135*	95,000	65,000	18	50	1.85
4150*	95,000	70,000	25	56	1.85
3140*	95,000	65,000	22	55	1.75
2340*	95,000	68,000	25	58	1.82
1030	95,000	65,000	24	55	1.67
4820*	92,000	65,000	25	60	1.82
6130*	90,000	60,000	25	60	1.82
5140*	90,000	55,000	25	55	1.82
4815*	90,000	70,000	28	65	1.92
4140*	90,000	65,000	28	58	1.79
3312*	90,000	75,000	28	62	2.00
3230*	90,000	65,000	25	54	1.92
3130*	90,000	60,000	30	55	1.79
6120	85,000	65,000	30	60	1.85
4620*	85,000	56,000	30	60	1.56
4130*	85,000	60,000	30	65	1.61
2330*	85,000	62,000	26	58	1.725
1040*	85,000	50,000	22	54	1.47
3220*	80,000	68,000	28	60	1.92
2515*	80,000	65,000	32	70	2.225
1035*	80,000	48,000	28	58	1.47
1112***	80,000	60,000	15	40	1.0
6120*	78,000	60,000	35	70	1.92
4615*	78,000	48,000	33	65	1.61
2320*	76,000	58,000	30	60	1.85
1030*	75,000	45,000	28	60	1.43
2315*	74,000	55,000	32	62	1.725
3120*	70,000	60,000	32	65	1.82
1020	65,000	40,000	32	60	1.92
X1020	62,000	48,000	30	58	1.61
1120	55,000	41,000	32	60	1.43




S.A.E. NO.
ULTIMATE STRENGTH LB. PER SQ. IN.
ELASTIC LIMIT LB. PER SQ. IN.
ELONGATION IN 2 IN. PER CENT
REDUCTION OF AREA PER CENT
BRINELL HARDNESS
100 140 180 220 260 300
MACHINING TIME INDEX
Hardness
Machinability Rating
MACHINABILITY COLD ROLLED STEELS
24 40 56 72 88 100
RATING, PER CENT

S.A.E. NO.	ULTIMATE STRENGTH LB. PER SQ. IN.	ELASTIC LIMIT LB. PER SQ. IN.	ELONGATION IN 2 IN. PER CENT	REDUCTION OF AREA PER CENT	MACHINING TIME INDEX
4150	145,000	130,000	14	35	2.225
2350	140,000	125,000	12	35	2.38
4140	130,000	115,000	16	45	2.08
3240	130,000	115,000	15	40	2.64
X3140	125,000	110,000	15	40	2.225
4130	116,000	95,000	19	50	1.92
2340	115,000	100,000	18	50	2.175
3230	115,000	95,000	16	42	2.27
3140	115,000	100,000	18	45	2.08
6135	115,000	95,000	20	50	2.08
2515	110,000	90,000	28	60	2.13
2330	110,000	90,000	18	50	2.08
6130	110,000	92,000	20	50	2.00
X1335	105,000	90,000	18	42	1.33
3220	105,000	85,000	20	48	2.00
X 1040	100,000	85,000	15	40	1.67
3130	100,000	85,000	20	48	2.08
4620	100,000	85,000	20	50	1.47
6120	100,000	85,000	22	55	1.92
4615	95,000	80,000	22	55	1.515
1040	95,000	80,000	16	40	1.61
2320	95,000	85,000	22	55	1.92
3120	95,000	75,000	22	50	2.00
2315	90,000	80,000	16	55	1.79
1035	90,000	77,000	18	42	1.54
1030	85,000	75,000	17	46	1.47
X1315	85,000	70,000	20	50	1.065
1112	80,000	60,000	15	40	1.00
X1020	80,000	65,000	20	50	1.43
1120	78,000	60,000	20	48	1.22
1020	70,000	60,000	22	50	1.725
1010	60,000	50,000	25	55	238

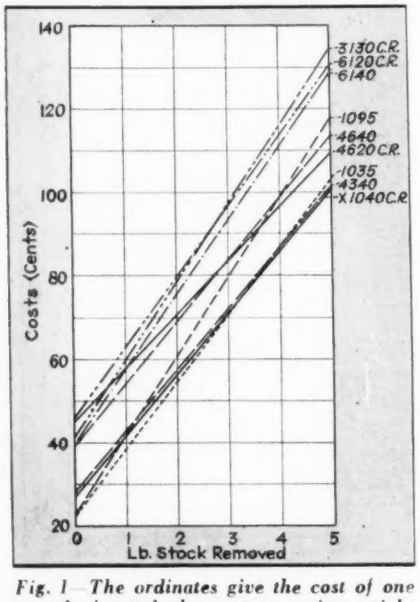


Fig. 1—The ordinates give the cost of one pound of metal plus cost removing weight of metal indicated by abscissa

sile value and find that there are five hot rolled and four cold rolled steels which will give the necessary strengths. The complete list which we will consider is given in Table III along with the other factors which must be considered.

For purposes of illustration we will also assume that this job is to be done on a lathe in our shop upon which we have the necessary data for the permissible surface speeds for the various machinability ratings. The feed is 0.009 in. per revolution and the depth of cut 0.125 in. The volume of metal removed per minute is

$$0.009 \times 0.125 \times \text{S.F.M.} \times 12$$

To make the illustration as factual as possible we have estimated the total machining cost as $1.80 per hr. or 3 cents per min. The cost of raw material will vary greatly depending on locality, and other purchasing factors and therefore must be considered only approximate. However, the relative costs are nearly enough correct for our purpose.

Table III—Relative Machinability of 9 steels All of 100,000 lb. per sq. in. Tensile Strength

SAE Steel	*Machinability Hot R.*	*Cold R.*	*Surface Speed (ft. per min.)*	*Volume Removed per min.*	*Minutes per lb.*	*Machining Cost ($1.80 per hr.)*	*Raw Stock Cost (approx.) (10 lb. piece)*
1035	58	..	46	0.621	5.35	16.0	22.5
1095	45	..	38	0.513	6.48	19.5	22.5
4340	58	..	50	0.675	4.93	14.8	28
4640	62	..	52	0.702	4.74	14.2	39
6140	50	..	42	0.567	5.86	17.6	40
6120	..	52	44	0.594	5.60	16.8	46
4620	..	68	57	0.769	4.33	13.0	45
3130	..	48	40	0.540	6.15	18.5	41
X-1040	..	60	50	0.675	4.92	14.8	27

The calculations for arriving at the cost of machining are included in Table III, as is the estimated cost of the raw stock. Machining costs are calculated for removing one lb. at a time. The total cost of material and machining various percentages of the original weight (or volume) are shown in Fig. 1. It will be noted that while several materials may have approximately equivalent original costs, the machining costs cause wide divergencies in the cost of the machined piece.

All of the above assumptions will vary according to shop practices and more particularly, according to the number of pieces to be made. The latter, for example, will affect the assumption of $1.80 per hour which we used for our own problem. At the same time, the selection of type of work; that is, whether it is milling, turning, shaping, boring or drilling will again change the amount of metal which can be removed per minute and will change the final cost figures.

There is one final factor which must not be overlooked in such a problem and that is the heat-treating requirements. It is quite possible that a steel can be selected for low-cost machinability, after which it will be found that the heat-treating requirements cause additional expense which has been overlooked, and which may change the picture completely. For that reason close cooperation between the metallurgist, the engineering department and production is always essential. Then, too, it may often appear that certain steels are outstanding as to low cost. However, consideration must be given in the final selection as to whether or not case-hardening, flame-hardening, or other type of heat-treatment is required for which that particular steel is unfitted.

SPOT WELDED JOINTS

Data and Procedure for Their Design in Various Metals

L. H. FROST
The Electric Controller & Manufacturing Company

A summary of data and tabulations for quick reference, together with details of the procedure in designing spot welded joints

IN THE PREPARATION of work for spot welding several factors must be considered if uniform results are to be obtained even though proper current, time and pressure values and the proper electrodes are used.

The surfaces which are to contact to form the joint must be flat so that the sheets at the point where the weld is to be made will be together. If the pressure forcing the electrodes into contact must be used in part to force the sheets together, the proper pressure for welding is not available. Further, the spring effect of warped sheets may be sufficient to weaken the weld or to cause it to fail when the welding pressure is removed, the weld metal still being hot. Uneven surfaces as in Fig. 1 should be avoided or necessary precaution taken to insure surface contact before the weld is made.

When welding near the edge of the material sufficient metal must be allowed between the weld and the edge to prevent burning or melting of the edge. In Fig. 2*a* the electrodes are too near the edge. Fig. 2*b* shows the proper arrangement and the distance *d* should be at least equal to the diameter of the electrode tip. If necessary to have the weld at the edge it may be advisable to first weld and then shear to size.

Another cause of improper welding which is sometimes overlooked is the possible deflection of the electrode arms. If the electrodes are dressed and trued in a lathe, the surface of the tip will be in a plane at right angles to the axis of the electrode. Under the condition of no pressure or light pressure the electrode tips will be in proper contact with the work. If deflection of the electrode arm occurs on account of heavy welding pressure, the position of the electrode tip surfaces may be as shown in Fig. 3. Under this condition the value of careful pressure, current and time control is lost since the welding conditions are no longer definite or uniform. A suggested solution might be ball or dome pointed electrodes but the increased cost of dressing such electrodes will usually more than offset the expense of putting the welding machine in the proper operating condition.

In previous articles (Jan., Feb., and May *P.E.*, 1938) the various factors that enter into the design of spot welded connections or fastenings were presented. In this article examples of typical designs will be given in order to show the procedure. For convenience, the various curves and tables of design data given in the previous articles are repeated here.

Spot Welding Mild Steel

Example—A straight line of spot welds is to be made to form a lap weld. Stock is 16 gage (0.062 in.) clean mild steel. Data for the design of this joint is obtained from the curves indicated.

Spot spacing—1.5 in. (Fig. 4)

Strength of spot weld—400 lb. per spot (Fig. 5)

Strength per inch of joint—400/1.5 or 266 lb. per lineal inch

If surface appearance is not of prime importance, a centered electrode with a 0.20 in. tip diameter should be used.

Normal welding time—12 cycles

Welding machine capacity required—33 kva. (Fig. 6)

Welding pressure—275 lb. (Fig. 7)

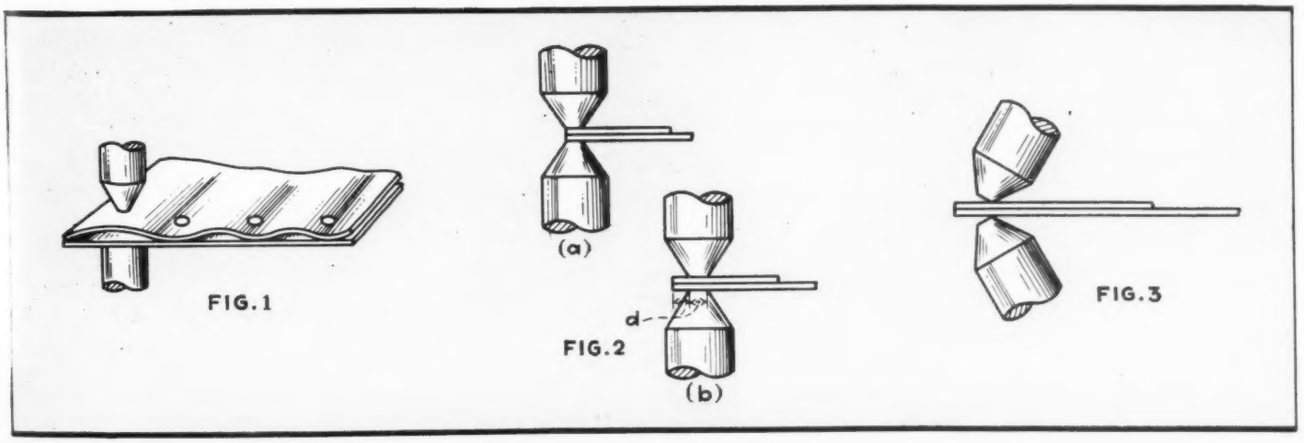
From the above, average speed will be 75 welds per minute. By increasing current and pressure, greater welding speed can be attained.

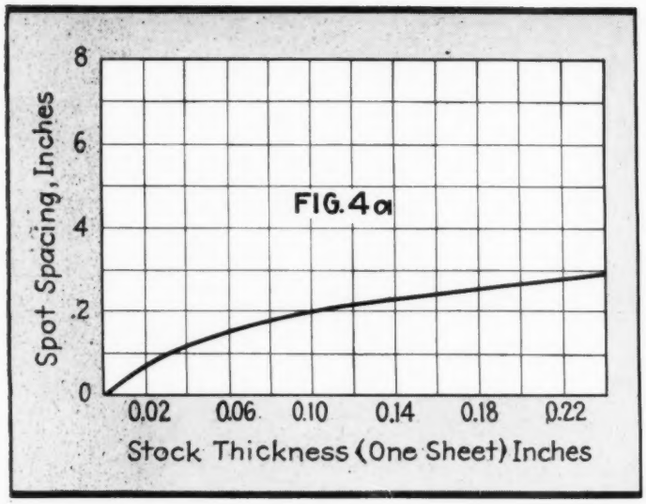
If stock surface has mill scale on it, pressure should be increased about 25 per cent, making total pressure required 275×1.25 or 345 lb. Presence of mill scale is usually evidenced by flashing. Heavily scaled stock should not be used as it requires greater electrode maintenance and usually results in bad surface marking and burning.

Welding Stainless Steel

If the sheets in the above example were stainless steel instead of mild steel, referring to Table I, the resistance of stainless steel is 35 times that of copper, whereas low carbon steel has a resistance of only 5.8 times that of copper. Roughly, stainless steel has a resistance 6 times

Three common causes for defective welding: Fig. 1—Wrinkled or warped sheets. Fig. 2—Welds too near the edge as at (a). The minimum edge distance should be (d), the diameter of the electrode tip. Fig. 3—Deflection of the electrode arms causing poor contact between electrodes and sheets





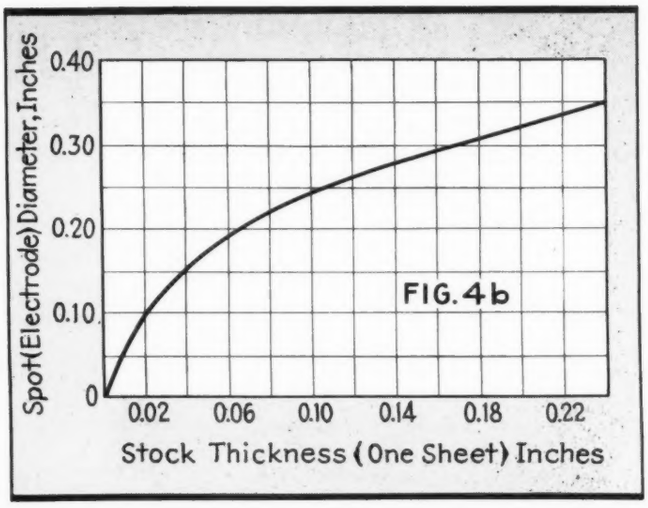


Fig. 4a and 4b—Spacing for spot welds and electrode diameter in clean mild-steel sheets of various thicknesses

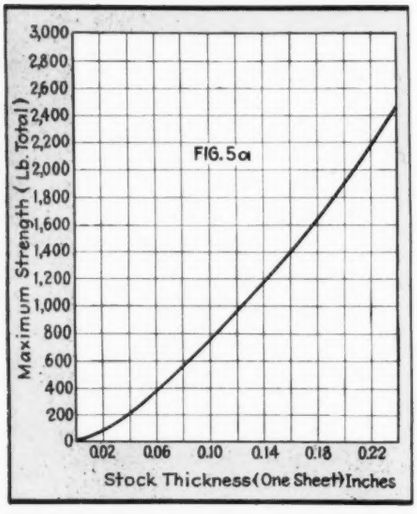


Fig. 5a—Tear strength of spot welds in sheets of various thicknesses, for spot diameters as determined by curve in Fig. 4b

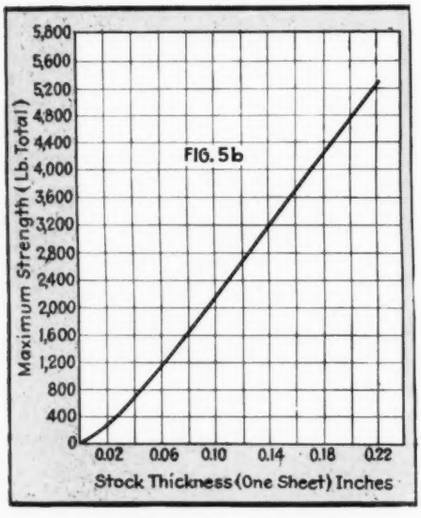


Fig. 5b—Shear strength of spot welds in sheets of various thicknesses, for spot diameters as determined by curve in Fig. 4b

that of mild steel. Since the contact resistance is determined primarily by the resistance of the material, surface conditions and hardness being equal, less current or less time (either or both), will be required for stainless steel as compared to mild steel. A general rule is that one-half the kva. and one-half the time is required.

For 18-8 chrome-nickel stainless steel, the possibility of carbide precipitation need not be considered unless the welding current period exceeds 30 cycles or ½ sec. The slight brown or blue discoloration may be observed on the surface of spot welds in stainless steel does not indicate a loss of corrosion resistance or stainless properties by carbide precipitation. The discoloration is merely an oxide that can be removed by buffing or polishing.

Data for the design of a stainless steel spot welded lap joint may be tabulated as follows from data obtained from Figs. 5, 6 and 7 and multiplied by the factor as specified in the tabulation.

Thickness.....16 gage—0.062 in.

Strength per lineal inch...400 to 530 lb. (From 1½ to 2 times that of mild steel)

Type of electrode.....centered

Diameter of electrode tip.....0.20 in.

Current period.....6 cycles (About ½ that for mild steel)

Transformer capacity.....17 kva. (About ½ that for mild steel)

Pressure .....275 lb.

Welding High Carbon Steel

In high carbon steel, rapid cooling of the weld metal and consequent hardening or embrittlement cause difficulties that must be avoided. Welding of high carbon steel can be done successfully by annealing. With steel of 60 carbon or less this is accomplished by using longer current periods as obtained by using a lower transformer capacity. The curves in Fig. 6 do not apply as they indicate the heat required for welding only, whereas in welding high carbon steel additional heat must be made available to obtain the annealing.

It is difficult to draw general conclusions as to the heat required for welding high carbon steel. Because the outer surface of the sheet will reach red heat during the welding operation, the electrode pressure must be a minimum, otherwise there will be indentations or excessive markings at the weld. Current should be less than normal to allow more time for heat to travel into the metal surrounding the weld. The longer time required will be longer than that required for mild steel at the lower current value.

The following tabulation may be used as a guide for designing spot welded lap joints in high carbon steel:

Thickness of sheets.....16 gage

Strength per lineal inch....400 to 500 lb. (1½ to 2 times that of mild steel)

Type of electrode.....centered

Diameter of electrode.....0.20 in.

Current period.....40 cycles (About 3½ times that for mild steel)

Transformer capacity.....15 kva. (Slightly less than half that for mild steel)

Pressure .....175 lb. (About 100 lb. less than mild steel)

Case Hardened Steel

Steel which has been case hardened can be welded in a manner similar to that of welding 60 carbon steel but with the time somewhat less, depending on the thickness of the case.

Steels Higher Than 60 Carbon

When the carbon content of the steel is higher than 0.60 per cent, a separate annealing process after welding is re-

quired. This may be done in a heat-treating furnace or, in some instances, on the welding machine. For the latter the welder is set for a much lower current.

In so far as the welding operation itself is concerned, the data and procedure is usually the same as for that tabulated above for 60 carbon steel.

Spot Welding Yellow Brass

Although the red brasses are difficult or impossible to spot weld, the common yellow brasses can be welded on a production basis.

Brass is essentially different in welding characteristics, as compared to steel, the principal difference being the small plastic range. When a weld is made in this material the weld is of cast structure indicating that the metal was molten. Careful control of the welding process must be maintained to prevent this molten material from reaching the outer surface. If this occurs a hole may be burned in the work due to the electrode pressure not being maintained while metal is flowing away from pressure areas. Excessive indentation at welds may be found, or sticking of brass to electrode will increase electrode maintenance.

The first step is to choose the proper shape and material of the electrode. The theoretical shape would be a spherical or ball point. The radius is determined by the material and sheet thickness but for general use a 1 in. radius has proven most satisfactory. In order that a maximum of heat will be concentrated at the inner surfaces between the sheets, the electrodes should be of highest electrical conductivity obtainable. In general this will preclude the use of tungsten-copper alloys. Cadmium-copper and chromium-copper have been found most satisfactory. If production speeds are not too great, copper is generally used.

Since the brasses have relatively high electrical conductivity, more current will be required to provide the necessary heat. Table I gives electrical conductivity compared to copper. Table II shows that the welding temperature is not as high as steel, therefore less time will be required. This shorter time interval is also required because of the rapid change from solid to molten condition. In general about 1.5 times the current and 0.5 times the current interval as used for mild steel will produce satisfactory welds. Pressure should be about 0.8 of that for steel. The strength of the welds will depend upon the particular alloy used; an approximate value, however, would be 2/3 that of mild steel. A tabulation is given below for annealed or soft temper yellow brass:

Thickness of stock....16 gage—2 sheets

Strength per lineal inch.....175 pounds
(About 2/3 that for mild steel)

Type of electrode
Ball pointed—1 inch radius

Current period.....6 cycles
(About half that for mild steel)

Transformer capacity.....50 kva.
(About 1½ times that for mild steel)

Pressure.....220 lb. total
(About 0.8 that for mild steel)

Spot Welding Copper

Copper, because of its high electrical and thermal conductivity does not give good results with resistance welding. The alloys of copper and silicon, however, do form good resistance welds and several of these alloys are available. Complete data on the alloy should be obtained to make certain that the proper welding characteristics are available.

Spot Welding Aluminum

Aluminum can be spot welded on a production basis. Like the brasses, aluminum passes rapidly from the solid to the molten state and hence requires careful control of the factors which influence the welding operation. Aluminum has a low electrical conductivity compared to the other commercial metals, being only 1.6 times the resistance of copper. This low resistance or high conductivity requires greater current values to provide the necessary heat. The rapid melting, high thermal conductivity and low melting point necessitate the use of small current periods.

Aluminum is now available in a number of alloys, but the alloys most suitable for spot welding are the purest alloys and having a soft or medium temper. The heat-treated strong alloys can be welded by this process but the extra precautions required limit the use on a production basis.

Since the conditions for welding aluminum are more critical than steel a set of data for aluminum welding is given in Figs. 8, 9 and 10. Fig. 8 shows the pressure required for various stock thicknesses. The welding machine must be designed so that electrodes contact the work with a minimum of hammer blow effect. This is important and machines not so equipped will produce erratic results. The electrode may be either ball point of 1 in. radius or of centered design but the latter design should have a slight crown on the contact surface. An angle of 7 deg. to the flat has been found satisfactory for this.

The current period is also important and Fig. 9 gives values of time for stock thicknesses. Since there is small variation in time allowable the timing device should be accurate. The current values required are much greater than for steel and it is not possible to obtain suitable welds by increasing the current period and decreasing the current. Machines suitable for welding aluminum require careful design and in general machines

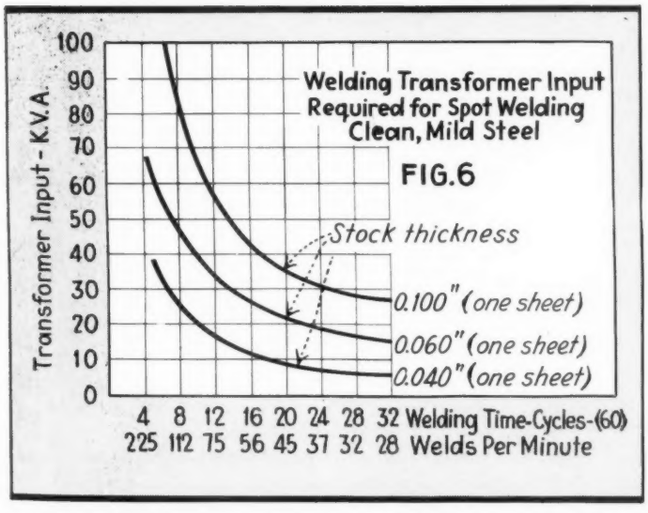


Fig. 6—Welding transformer input required for spot welding clean mild-steel sheets of various thicknesses

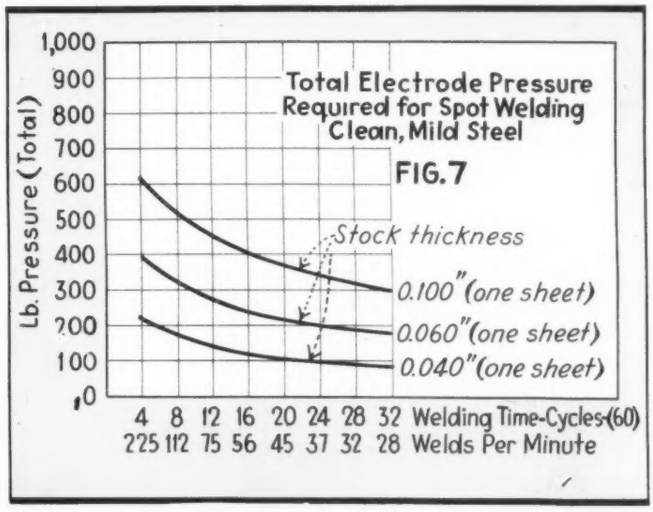
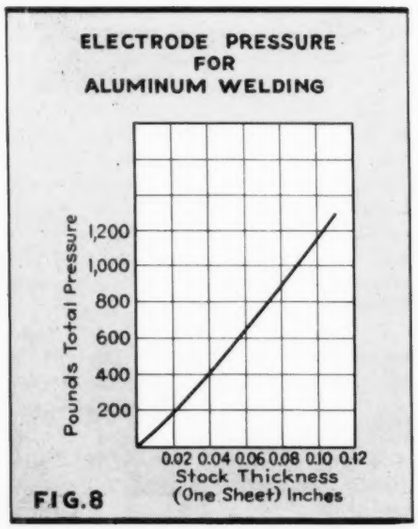
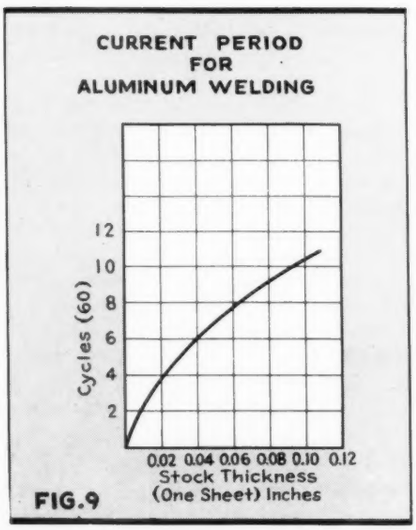
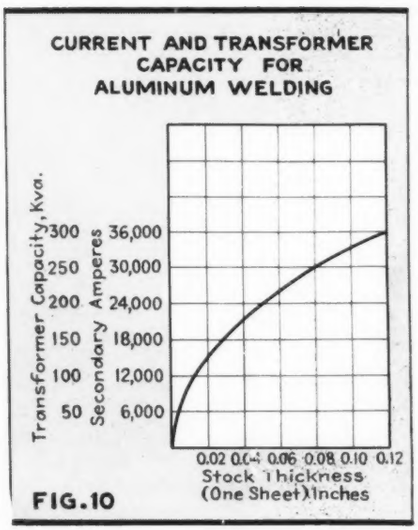


Fig. 7—Total electrode pressure required for spot welding clean mild-steel sheets; the welding time and welds per minute







Figs. 8, 9 and 10—Data for designing spot-welded joints in aluminum

for welding steel are not suitable.

The strength of welds obtainable in aluminum is less than that for steel and can only be determined from test. Data on strengths obtainable with various alloys should be obtainable in the near future. A tabulation for aluminum is as follows, the data being obtained from Figs. 8, 9 and 10:

ALUMINUM

Thickness of stock....16 gage—2 sheets
Strength per inch.....Depends on alloy
Type of electrode
Ball point—1 in. radius
Current period.....7 cycles
Transformer capacity.....225 kva.
Pressure.....600 pounds total

The above data are based on two sheets of equal thickness and are applicable only where surface appearance is not of prime importance. If surface appearance is of importance, a flat electrode may be used in conjunction with one surface and the electrode as selected above used with the other. In welding scaly stock, surface marking may be apparent and is due to high concentrations of current because of varying resistance of scale. No method can be recommended as insuring good surface conditions with scaly stock. The current required for welding scaly stock is usually substantially the same, though slightly larger current values may be required in some instances.

When the two sheets are not of the same thickness, the thinner stock is usually the determining factor rather than the thicker stock. The pressure is determined by the thinner stock. The current and time may be somewhat greater but in general the size of the weld is determined by the thinner stock.

Another method of minimizing surface marking is the so-called "slug" weld illustrated in Fig. 11. With this method a small piece of metal is placed between the sheets where the weld is to occur.

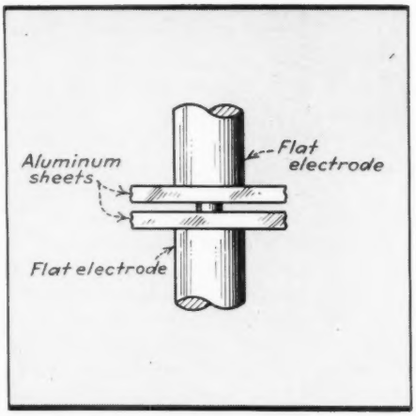


Fig. 11 To minimize surface markings, this so-called "slug weld" can be used for aluminum sheets. Using a low-carbon steel slug, this method is also used for welding high-carbon steel sheets

Indentation or deformation of the metal at the weld is then unnecessary. This method may also be used to weld high carbon steel by using a "slug" of low carbon steel. The weld will then be of lower carbon than the parent metal.

Table I—Electrical Resistance of Various Metals with Respect to Copper

Copper = 1.00

Metal	Resistance Factor	Metal	Resistance Factor
Silver	.95	Brass	4.5
Gold	1.4	Nickel	4.5
Aluminum	1.6	Platinum	5.8
Chromium	1.6	Steel	5.8
Magnesium	2.7	Tin	6.7
Manganese	2.9	Lead	12.8
Tungsten	3.2	Antimony	24.2
Zinc	3.5	Stainless Steel	35.0

Table II—Melting Points of Various Metals

Metal	Melting Point, °F.	Metal	Melting Point, °F.
Tin	450	Copper	1981
Lead	621	Manganese	2300
Zinc	787	Nickel	2646
Antimony	1166	Chromium	2768
Magnesium	1204	Steel	2786
Aluminum	1218	Platinum	3191
Brass	1700	Molybdenum	4500
Silver	1761	Tungsten	5400
Gold	1945		

Current Quotations

"If credit is due anyone (*for noteworthy flights*) it is due the men who designed and perfected to its present remarkable state of efficiency the modern American flying machine and its equipment. If we made a fast flight, it is because many young men in this country went to engineering schools, worked hard at drafting tables and designed a fast airplane and navigation and radio equipment which would keep this plane upon its course."—HOWARD HUGHES, *after completing his record-breaking round-the-world flight; also quoted by Boake Carter.*

"When the results of research are called 'negative', it is generally understood that they failed in some way to meet expectations. To throw such results into the waste basket is a natural inclination, but to do so would be foolish. What was discovered . . . may be valuable for its own sake. Industry is not built by refraining from taking action. To receptive and imaginative minds negative results act as a spur and a guide."—HURLBURT S. JACOBY, *research director, Ohio State University Research Foundation.*

INDUCTION MOTORS

For Frequent Starting and Rapid Reversal

T. C. LLOYD, *Robbins & Myers, Inc.*
W. A. THOMAS, *Iowa State College*

Part I. An analysis and discussion of the problems that confront electrical and mechanical designers when selecting electric drives for quick-starting and rapid-reversing machines

ELECTRIC MOTOR drives for modern machines have given rise to a number of problems, chief of which is the avoidance of overheating. Motors which display satisfactory operating characteristics on "general purpose" duty may be found to overheat rapidly on certain applications. This overheating may occur even though meters reveal that the motor load is not in excess of rated values.

The problems which arise will be discussed here from the standpoint of the electrical designer, but in not too technical a manner, so as to acquaint the mechanical designer with the nature of the problems his devices have given the motor industry.

Broadly speaking, electric motor drive has been applied to machines in which (1) by manual control the operator in working steadily subjects the motor to a fairly constant cycle of operations; and (2) by automatic control the motor goes through a regularly repeating cycle of operations, when once started by the operator.

Such cycles of operation take on various forms. If the load fluctuates from no-load to slight overload, no special problem is introduced so long as:

1. The greatest load does not exceed the maximum which can be developed by the motor.
2. The slight speed change introduced by varying load does not interfere with the work.
3. The losses in the motor average out in such a way as not to result in abnormal temperature rise.

Cycles of operation which are especially troublesome include frequent starting and frequent reversal. It is not unusual for an automatic machine tool manufacturer to expect a motor to start and reverse 40 times per min. Great care is required in recommending a motor for such application, for excessive temperature rise is bound to occur unless unusual ventilating means are used, oversized motors are specified, or rigorous engineering analyses used in design.

In a polyphase induction motor, the current at the instant of full voltage starting may be 5 or 6 times its rated value. This current reduces gradually as the speed picks up, but if it averages 3 times normal the copper losses would be 9 times rated values. If such a motor starts many times during its operating cycle drastic overheating may readily occur.

On examining one trial set-up, it was found that the motor never quite came up to speed; the automatic control cut out and the motor had finished its work before the current reduced to normal value. As a result, the machine was operating continuously with several times rated current, yet the useful mechanical output was a small fraction of the energy input.

Rapid reversal with braking action is useful in many applications. The polyphase induction motor can be effectively reversed by "plugging." That is, while operating in one direction, two of its input leads are reversed. This reverses the motor's field, bringing about rapid deceleration, an instant of standstill, and immediate acceleration in the opposite direction. The reversed torque produced gives effective motor braking.

The variety of operations that can occur in a duty cycle require investigations of time required to accelerate, time to reverse by plugging, and the losses during each action.

Losses during acceleration can be determined without knowing the time required for starting. However, it is frequently necessary that the designer check the accelerating time, inasmuch as the duty may be governed by automatic control which is set for a definite time. Should the motor actually require a longer time to get up to speed, its current will never decay to normal on this application. Methods, which have been checked experimentally, for obtaining quantitative results for starting and plugging times will be presented here.

Calculations pertaining to the heat generated during starting or plugging duty and the resulting temperature rise

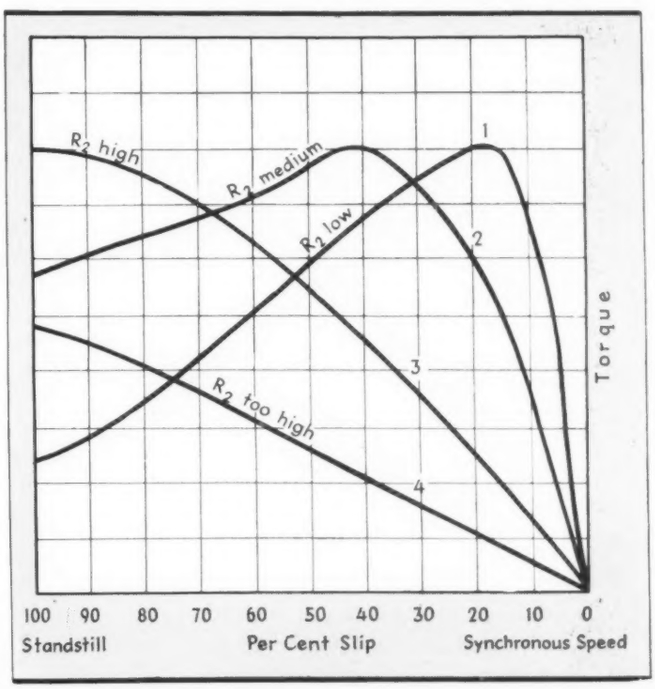


Fig. 1 Typical speed-torque curves of a polyphase induction motor. Note that the maximum torque is not influenced by the rotor resistance R_2, except in some special designs

constitute a more complex problem. Heating effects arise chiefly from the copper losses. The most practical approach to the determination of these losses is based on this fact: During the acceleration of a mass by a polyphase motor, the energy which has been converted into rotor copper losses is exactly equal to that stored in the moving mass.

This is at once a useful tool and an unfortunate fact. It means that to bring a load of a fixed inertia up to a given speed, the heat generated in the rotor is a fixed value. Up to a certain point increased rotor resistance will result in more starting torque and reduced starting time. No matter, the heat generated in the rotor will be the same even though low rotor resistances were used and the starting time were twice as great. Nothing but a reduced inertia of the moving parts will effect a reduced rotor loss in starting. Hence to obtain quantitative values for this loss and the starting or plugging time, it will be necessary to determine the inertia of the moving parts. Test and calculation methods will be shown in Part II for determining this inertia.

To find the time t in sec. required to reach a final speed when a constant torque is applied to an inertia load, where

W = weight of the rotating parts in lbs.
R = the radius of gyration in ft.
J = the polar mass moment of inertia
$= WR^2/32.16$
T = the torque in lbs. ft.
S = the slip expressed as a decimal fraction
Final r.p.m. = Synchronous r.p.m. $\times$ $(1-S)$

$$t = \left(\frac{2\pi}{60}\right)\left[\frac{J \times (\textit{Final r.p.m.})}{T}\right] \qquad (1)$$

In Equation (1) it is considered that a constant torque has been applied to the load. In an induction motor the torque developed is a function of the speed. Hence, as the motor accelerates the torque varies, and expressions for time must take into account the summation of the instantaneous values of torque, based on an expression for torque in terms of speed. Such speed-torque curves are of the familiar form shown in Fig. 1. Numerous equations are available for them, the simplest being based on an approximate equivalent circuit for the motor, neglecting the effect of magnetizing current. For greater accuracy, with approximate correction for this current, an equation will be used, in which

J = the mass moment of inertia. Methods of obtaining this value will be shown
X = the total leakage reactance of the induction motor per phase
X_0 = the total magnetizing reactance per phase
K_r = a flux factor $= \dfrac{X_0 - X}{X_0}$

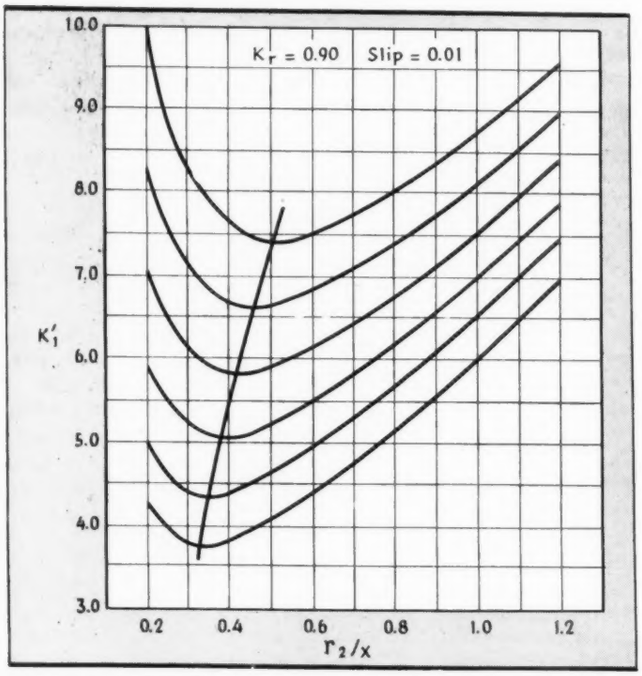
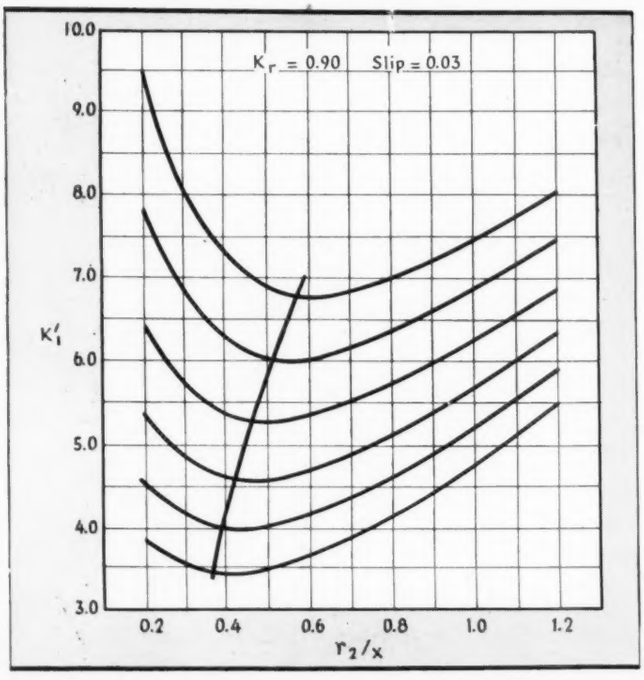
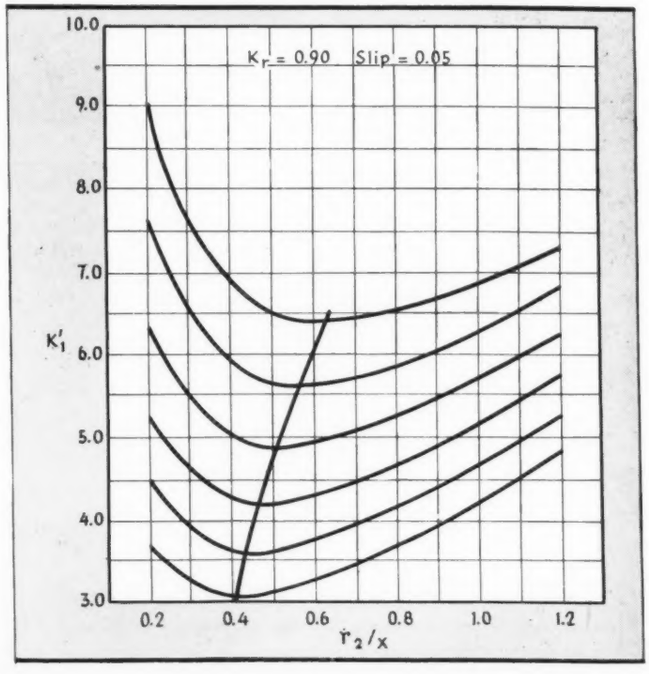


Fig. 2 — Curves giving values of K'_1 for various ratios of rotor resistance per phase and the total leakage reactance of the motor per phase, for a flux factor of 0.90, (a) with 0.01 slip, (b) with 0.03 slip, (c) with 0.05 slip





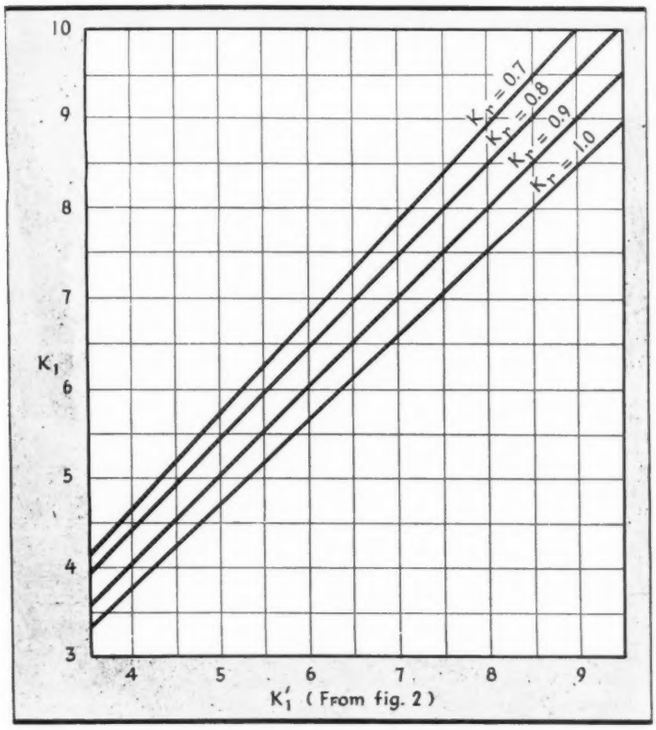


Fig. 3—When the flux factor is other than 0.90 these curves are used to determine final values of K_1 in terms of K'_1 taken from Fig. 2 readings

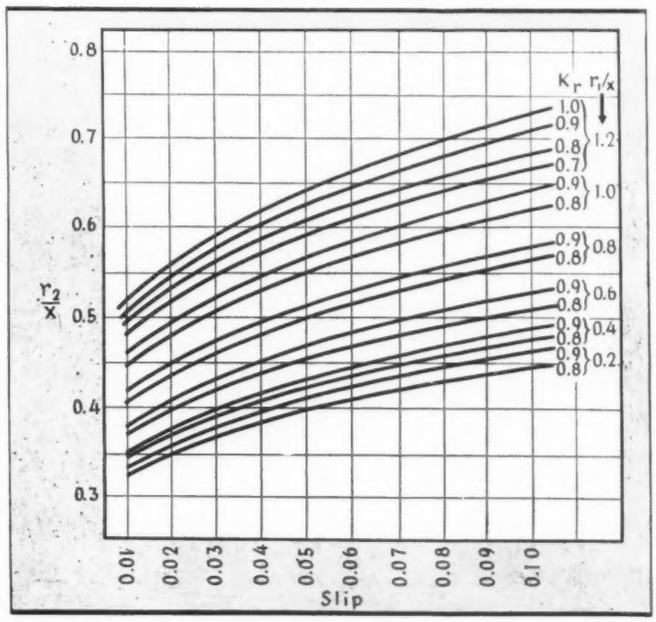


Fig. 4—Curves giving relationship of constants for acceleration in minimum time

r_1 = the stator winding resistance per phase

r_2 = the rotor resistance per phase in stator terms

P_0 = power per phase converted to mechanical form
= [(hp. output × 746) + (Friction loss of the motor)]/n

n = the number of phases

V = the applied voltage per phase

S' = the final slip. This can be determined by test or calculated as

$$= \frac{r_2}{(V^2/P_0) - 2r_1 - r_2} \qquad (2)$$

$$\text{Torque} = 7.04\ V^2\ r_2\ n\ S \div \left\{ (Syn.\ r.p.m.) \times \left[\left(\frac{2\ r_2}{1 + K_r} \right)^2 + (r_1^2 + X^2)\ S^2 \left(\frac{2}{1 + K_r} \right) + (2\ r_1\ r_2\ S) \right] \right\} \qquad (3)$$

Substituting Equation (3) for torque in Equation (1) and integrating between the limits of slip equals 1 (standstill) to a final slip of S′ gives the time of acceleration in sec. as

$$t = 0.01487 \left[\frac{J \times (Syn.\ r.p.m.)^2}{V^2\ n} \right] \times \left\{ r_2 \left(\frac{2}{1 + K_r} \right)^2 \log_e \left(\frac{1}{S} \right) + 2\ r_1\ (1 - S') + \left(\frac{2}{1 + K_r} \right) \frac{(r_1^2 + X^2)\ [1 - (S')^2]}{2\ r_2} \right\} \qquad (4)$$

Unfortunately this formula is tedious to apply to routine calculations. Some advantage is obtained by expressing it in terms of ratios r_1/X, r_2/X and K_r Then

$$t_s = 0.01487 \left[\frac{J \times (Syn.\ r.p.m.)^2 \times X}{V^2\ n} \right] K_1 \qquad (5)$$

K_1' is read from Fig. 2 for the proper values of r_2/X and r_1/X. If the slip differs from that for which values are shown, interpolation must be used. Then correct for K_r as shown in Fig. 3 obtaining for K_1 a final value.

It will be noted from the plotted values of K_1' that as the the machine constants are progressively varied the time required for acceleration will go through a minimum. Rotor-resistance and resistance-reactance ratios yielding a minimum time are then:

$$r_2 = \sqrt{\frac{(X^2 + r_1^2)\ (1 + K_r)\ [1 - (S')^2]}{9.2 \log_{10} (1/S')}} \qquad (6)$$

or r_2/X

$$= \sqrt{\frac{[1 + (r_1/X)^2]\ [1 - (S')^2]\ (1 + K_r)}{9.2 \log_{10} (1/S')}} \qquad (7)$$

The graphs in Fig. 4 show the relationship between r_2/X and r_1/X for various values of slip.

Up to this point it has been assumed that all of the torque developed by the motor has been available for accelerating the rotor and its connected load. In some installations the friction, either of the motor bearings, or of the motor and load, may increase the time of acceleration. True results must be based on an analysis taking into account a net or effective torque:

Effective torque = developed torque — friction torque

Friction torque varies with speed; it will be assumed to vary with the 1.5 power of the speed, which is a good approximation. It is necessary to know the friction torque at some r.p.m. Then:

Friction torque $T_F = K_F\ (1 - S)^{3/2}$

$$K_F = \left(\frac{Syn.\ r.p.m.}{\text{R.p.m. at which friction is known}} \right)^{3/2} \times (\text{known friction torque})$$

To obtain final results it is necessary to expand T_F by the binominal theorem, to arrive at an expression for net torque that can be integrated. This yields the following expression for the time required for acceleration, with the retarding effect of friction considered:

$$t = \frac{0.01487\ J \times (Syn.\ r.p.m.)^2}{V^2\ n} \times \left\{ r_2 \left(\frac{2}{1 + K_r} \right)^2 \log_e \left(\frac{1 - F}{S' - F} \right) + 2\ r_1\ (1 - S) + \frac{(r_1^2 + X^2)}{r_2\ (1 + K_r)} [1 - (S')^2] \right\} \qquad (8)$$

where $F = \dfrac{K_F\ B}{A}$, in which $B = \left(\dfrac{2\ r_2}{1 + K_r} \right)^2$

and $A = \dfrac{7.04\ V^2\ r_2\ n}{Syn.\ r.p.m.}$

Examples investigated indicate that the time is increased very slightly by friction losses or friction loads. It is impracticable to attempt any plotting of values for Equation (8) to provide useful "shortcuts." The application of this method of procedure will be illustrated by an example in Part II of this article. Part II will also discuss the loss in the rotor during acceleration, losses during complete reversal, methods of calculating inertia and also testing methods.

HEAVY-DUTY BEARINGS

Performance of Various Materials Under Load

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Westinghouse Electric & Manufacturing Company

Discussion of forced-feed lubrication, effect of loading on friction coefficients, and a brief summary of the characteristics of materials used for heavy-duty service

SUCCESSFUL performance of heavy-duty bearings today is the result of the numerous combined investigations of research and field engineers which have progressed along the three lines of (1) Bearing performance involving the fundamentals of dry, semi-fluid and fluid friction; (2) Metallurgical and physical investigations in connection with improving, and developing new, bearing materials, (3) Development of suitable lubricants.

Performance of plain bearings, well covered in present scientific and technical literature, can be rather closely predicted on the basis of hydrodynamical theory. This can be simply shown by the agreement of calculated data with those obtained during experiments at loads up to about 1,000 lb. per sq.in. of projected bearing area. Only at the highest loads now used, as in heavy-duty roll-neck bearings in steel mills, was a discrepancy observed between theoretical and experimental data. (Ref. 1.)

It was found, as can be seen in Fig. 1, that at loads of several thousand lb. per sq.in. the friction coefficient curve reached a minimum value after which it began to rise with increased load. Since no metal to metal contact occurred during these experiments, the discrepancy between observed and calculated values suggests the probability that the high pressures in the bearing oil film causes an increase in film viscosity. Contrary to what occurs in ordinary bearings, where the viscosity variation with pressure is negligible, in heavy-duty bearings apparently the change of oil film viscosity with pressure is large.

Actual heavy-duty bearings perform at the low values of ZN/P as given in Fig. 2. In roll-neck bearings at a bearing pressure of 2,500 lb. per sq.in. of projected area, 40 r.p.m., and heavy oil having 250 centipoises viscosity at the operating temperature, the value of ZN/P is equal to four.

Heavily loaded bearings are sometimes provided with forced feed lubrication (Ref. 2). Powerful pumps supply the lubricant at high pressures, 100–200 atmospheres, for the purpose of eliminating the possibility of metallic contact. A performance of a bearing with ordinary and forced feed lubrication was compared during tests and the data obtained are plotted in Fig. 3. For the journal bearing without pressure lubrication the friction was found to be much greater than for high pressure lubrication.

Bearing Materials

Among bearing metals for heavy-duty bearings the cadmium base alloys should be mentioned first. A small addition of nickel to cadmium, itself a very soft metal, results in an alloy well suited for bearing application (Ref. 3). Most of the physical properties of cadmium-nickel alloy are superior to those of babbitt and the alloy is harder than babbitt (Ref. 4), as seen in the table above.

Tension tests were made at various temperatures. The 3 per cent nickel alloy had a tensile strength more than twice that of the babbitt alloy at room temperature, and at 212 deg. F. (100 deg. C) it was two and one-half times as strong. Creep tests also indicated the superiority of this alloy over babbitt. The comparison of compression tests at two elevated temperatures is shown in

Fig. 1—Variation of friction coefficient with load, using lubricants of the same viscosity at atmospheric pressure and test temperature, according to S. J. Needs

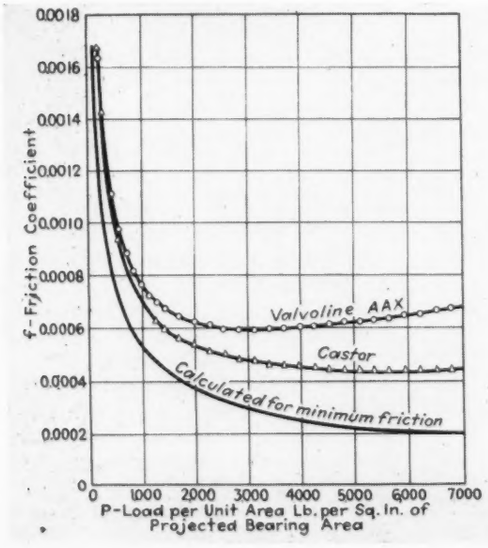
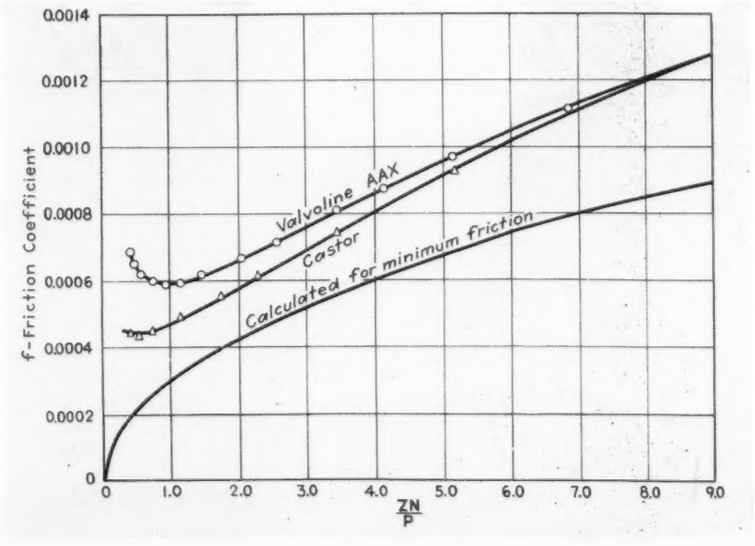


Fig. 2—Variation of friction coefficient, according to S. J. Needs



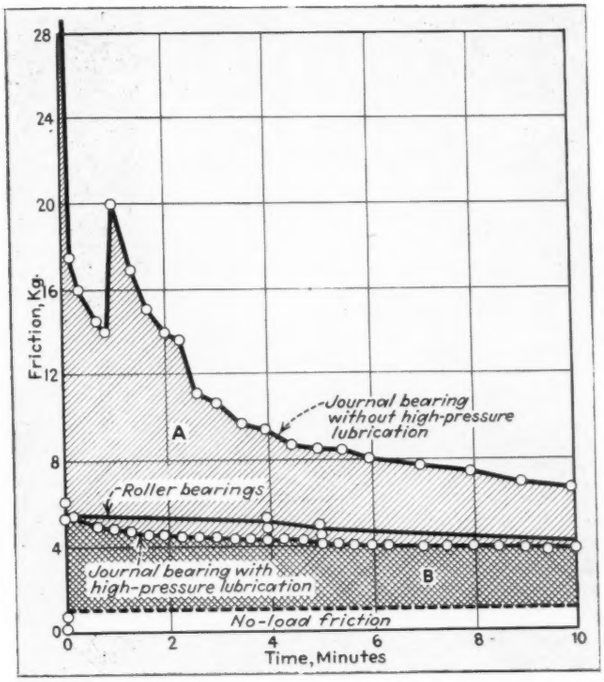
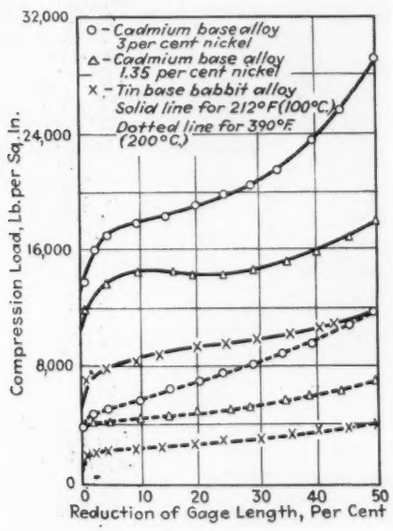


Fig. 3—Performance of bearings under ordinary and under forced-feed lubrication, according to G. Welter and W. Brasch

Alloy	82 deg. F (28 deg. C) 500 kg	212 deg. F (100 deg. C) 500 kg	390 deg. F (200 deg. C) 250 kg	570 deg. F (300 deg. C) 100 kg
	BRINELL NUMBER			
Tin base 5.23 per cent Cu 6.2 per cent Sn	24.4	12.4	3.7	molten
1.3 per cent Nickel, remainder Cadmium	33.2	21.9	6.5	1.8
3 per cent Nickel, remainder Cadmium	47.5	28.4	8.3	1.9

Fig. 4. Another big advantage of nickel-cadmium alloys is that they bond directly to steel or bronze without formation of an intermetallic compound at the junction between the alloy and shell.

Fig. 4—Compressive stress-strain at elevated temperatures, (Swartz and Phillips)


O – Cadmium base alloy 3 per cent nickel
Δ – Cadmium base alloy 1.35 per cent nickel
X – Tin base babbit alloy
Solid line for 212°F (100°C.)
Dotted line for 390°F (200°C.)
Compression Load, Lb. per Sq. In.
Reduction of Gage Length, Per Cent

Synthetic resin bonded materials also prove to be well suited for heavy-duty bearings. Whether lubricated with water or oil, they sometimes perform better than bronze bearings. Especially in case of semi-fluid friction, oil or water-lubricated fabric bearings will probably give lower frictional loss and longer life. As an example the use of fabric bearings fitted to two welded tube mills resulted in a power saving of 30 per cent. The previous bronze bearing lasted some eight to ten weeks (Ref. 5); the life of the fabric bearing was between eight and nine months.

Anti-friction Bearings

Anti-friction bearings for heavy-duty application are also used extensively. Friction losses of this type of bearings are low, as can be seen in Fig. 3. Extensive research pertaining to roller and ball bearing performance, physical properties of material used, and lubrication (Ref. 6, 7) is still in progress.

In heavy-duty service, pure mineral oils and high grade greases are used for metal and anti-friction bearings respectively. Water—as lubricant—is used for fabric and for synthetic resin bonded bearings.

Extensive chemical research is being carried out by various oil companies, with the object of improving the lubricating qualities of mineral oils. (Ref. 8, 9). In addition to the fundamental improvement of some, or many, of the physical properties of oils, new methods are being devised for the pumping, storing, cooling and filtering of various grades of lubricants. In this connection it is of interest to mention the application of magnetic filters installed in lubricating systems (Ref. 10). Such magnets remove minute particles of iron which would pass through ordinary filters into the bearing clearance.

This condensed review of materials for the heavy duty bearings would not be complete without mentioning the importance of the surface finish of journals. As pointed out many times before, the smoother the shaft surface, the better the bearing performance. For example, many of the roll-neck bearings of present steel mill rollers are "mirror finished" which undoubtedly contributes to the successful performance of the heavy-duty bearings.

Research along the above three lines is continually going on for clearing up still indefinite phases and opening new ones for further improvement and stepping-up of overall efficiency in performance of heavy-duty bearings.

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IMPROVING PRODUCTS

Through Research and Tests for Quality

S. KEILIEN
Pass & Seymour, Inc.

Test requirements, procedure and apparatus employed in maintaining standards of life and performance to make wiring devices safe and hazard free units for electrical installations

WIRING DEVICES are relatively inexpensive, and in the mind of a layman sockets, switches and convenience outlets are merely devices for occasional use, carrying small currents and, therefore, not particularly needing dependability in operation, space and labor saving features, strength or long life and safety, all of which are required of more expensive electrical apparatus, such as motors, domestic and industrial appliances.

Such a viewpoint is erroneous, for wiring devices fall in the category of electrical equipment, and as such they must possess the same basic qualities of performance and of safety demanded of more elaborate and more costly apparatus. As result of imposing these stringent requirements the hazard caused by any imperfection in construction of the devices or by their use has been almost eliminated.

To bring about such a degree of dependability, wiring devices must be subjected to a thorough investigation prior to their acceptance for quantity production, and must be tested during their manufacture to assure the maintenance of the standard set up by engineering considerations.

The minimum test requirements for current-interrupting wiring devices as specified by the Underwriters' Laboratories, Inc., fundamentally are:

1. Overload Test—50 operations at 150 per cent rated current, at rated voltage
2. Endurance Test—6,000 operations at rated current and voltage
3. Heat Test—to determine the maximum temperature rise, with rated current passing through the device
4. Dielectric Strength Test—application of high voltage between current carrying parts, as well as between these parts and the "grounded" member of the device.

In addition there are mechanical strength tests, also tests for special application devices, such as switches intended for the control of tungsten filament lamps and switches used for controlling motors.

To assure a factor of safety in operation the device should be capable of controlling greater than rated load. Since the detrimental effect of the arc on current-interrupting parts (contacts) becomes more pronounced with increased current (at rated voltage) the device

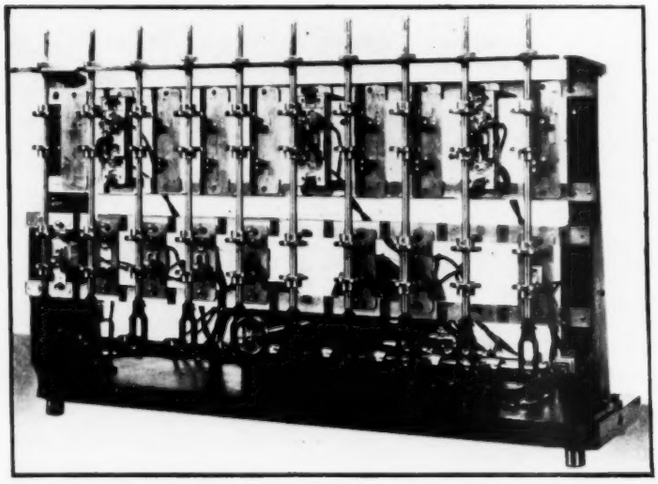


Fig. 1—Motor-operated machine for testing 10 toggle switches simultaneously for endurance. This switch testing machine also permits the removing and mounting of the test switches without stopping the driving motor

Fig. 2—Machine for testing the performance of pull-chain devices. This machine can accommodate 6 devices

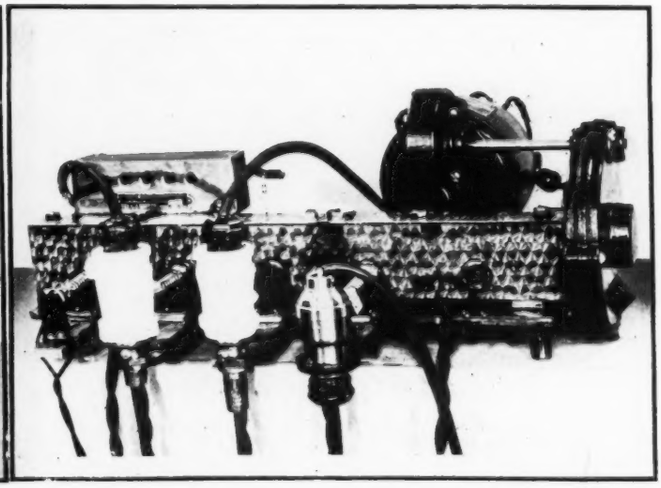


Fig. 3—Key socket testing machine, note the adapter brackets for the different types of sockets

under test is called upon to interrupt a load 50 per cent greater than its rated value.

For the overload test d.c. is employed unless the device is specifically designed for a.c. application. Non-inductive resistance is used as load for d.c. tests. With a.c. the device is subjected to a test with an inductive load of 0.75 to 0.80 power-factor. The test load for a switch intended for the control of d.c. motors consists of a non-inductive resistance which permits a current flow of 10 times the full-load current of motor. For a switch designed to control a.c. motors an inductive load of 0.40 to 0.50 power-factor is employed, the value of load being 6 times the full-load motor current.

Load Adjusting Facilities

Since the overload test is conducted with only 50 operations, no mechanical means is provided for the operation of the device. Suitable protection in the form of an overload circuit-breaker and a switching arrangement for selecting the proper source of supply are included to conserve time. The selection of the load and the adjustment of its value is facilitated by using a cross-connecting switchboard. Provision is made on the overload switchboard for easy introduction of measuring instruments without interference with the test. A "grounded" stand is used for mounting a variety of devices during the test. A signal to indicate the condition of the "ground" fuse is mounted in view of the operator.

If the device successfully interrupts the specified overload for 50 cycles or operations it is then considered ready for endurance tests. The endurance test is intended to determine the life of the device by repeated operations, the minimum acceptable number of operations is 6,000, using the rated load.

Since the endurance test is lengthy, mechanical means or test machines are employed to operate the devices. These machines simulate the movements of manual operation and are adapted for simultaneous working of several devices. Figs. 1, 2 and 3, respectively, illustrate test machines for toggle switches, for "pull-chain" devices and for "key" and other rotary devices. Counters mounted on the machines determine the number of operations. All the machines are designed for easily changing and connecting the test specimens. The switch machine shown in Fig. 1 permits removal and mounting of the test switches without stopping the motor.

To facilitate proper connection of the devices, various switchboards are provided. The four switchboards shown in Fig. 4 are designed to furnish power supply, protection and automatic control for machine operation of test switches. Each switchboard is arranged for 5 switch positions, with an overload circuit-breaker in each position. Selector switches are designed so that a d.c. supply source of 125 or 250 volts, or a supply source of single phase a.c. 115 or 230 volts may be connected to the switch under test. Combination knife switches permit single or double-pole type test specimens to be connected properly.

Analyzing Failure

In determining the qualities of a switch, it is important to know the causes of its failure. If the test were permitted to run indefinitely, the switch would often be completely destroyed, and it would be difficult to analyze the factors causing failure. To prevent destroying the test specimen, control relays are so arranged that in the event of switch breakdown, the supply circuit is interrupted, the motor operating the test machine stops, and a visual as well as an audible signal is given, indicating the specimen that has failed. This arrangement not only presents means for a correct picture for failure analysis, but also provides data for the rectification of imperfections in the design and in manufacture.

The test equipment described is sufficiently flexible to permit connection of any load to any switch. This is accomplished at the cross-connecting switchboard, shown in Fig. 5. On this board are brought to special jacks the ends of various resistance units (mounted above the board), reactances (mounted in rear), and lamp banks (mounted on ceiling). The lamps are connected through selector relays. The "load" connections from the test positions on the endurance test switchboard are brought to another group of jacks on the cross-connecting board. By means of flexible plug cords it is possible to connect any load consisting of a combination of resistances, re-

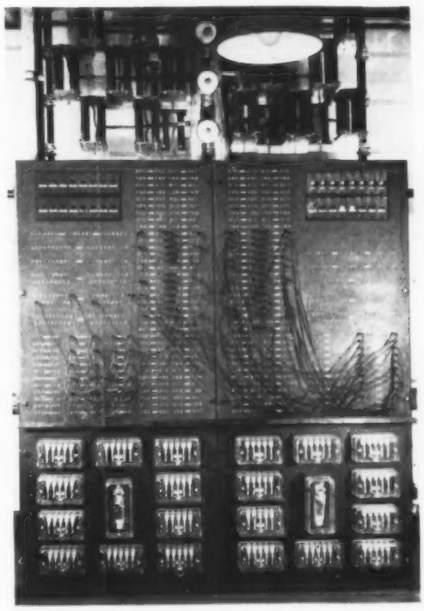


Fig. 5—Cross-connecting switchboard to which are brought connection cords from various circuit and loading units

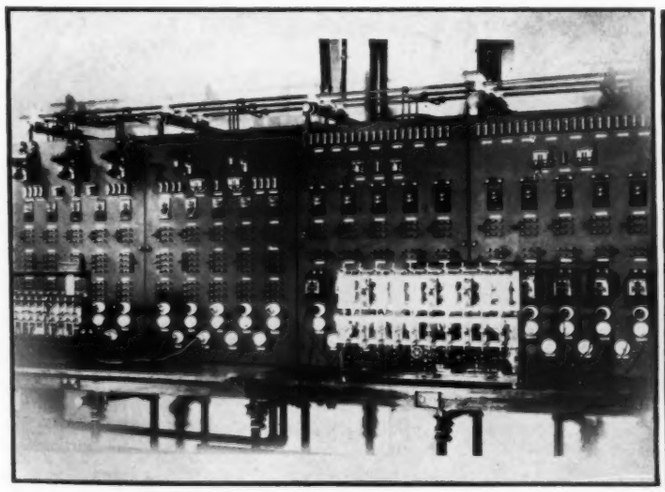


Fig. 4—Four switchboards designed to furnish power supply, protection and automatic control for machine operation

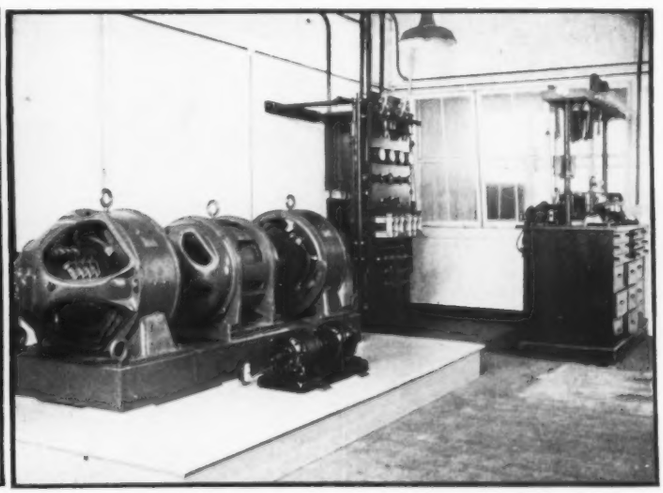


Fig. 6—Power supply unit, an a.c. motor and 2 d.c. generators. The generators can be connected in series or in parallel

Fig. 7—Special mechanical testing machine for measuring torques and pull out forces. Simple adapters are used to make it convenient to receive wiring devices for twisting or pulling tests

Fig. 8—Corner of research laboratory which contains a Kelvin double bridge for low resistance measurements, a Wheatstone bridge for medium measurements, an oscillograph and additional associated devices

Fig. 9—Oscillograph fitted with special drum-type film-holder, the oscillograph shutter is synchronized to coincide with the operation of the switch that is undergoing test

actances or lamps to any switch position.

In almost every field of illumination the contemporary tendency is to raise the light intensity, this calls for larger lamps. The increased lamp-load demands a stronger and better switch than that required for ordinary loads because of peculiar characteristics of tungsten-filament lamps. The testing of switches intended for the control of tungsten-filament lamps presents problems different from those involved in resistance-load testing. When a cold lamp of this type is connected to a source of e.m.f. a current considerably greater than the normal lamp current will flow for a short interval, which is primarily caused by the high temperature coefficient of resistivity of the filament material. This resistance increases with rising temperature, therefore, as the filament is heated by its resistance to the passing current, the resistance increases and causes a corresponding decrease in current.

Because of this characteristic the hot resistance of the lamp is higher than when it is cold, the ratio being about 15 to 1. A similar ratio of initial peak current to final current can be expected. However, the average ratio is approximately only 8 to 1, as the peak current is dependent on the capacity of current source, impedance of the circuit and voltage stability, all of which tend to reduce the magnitude of the peak. On the basis of these data, a switch controlling a 10-amp. lamp-load would be subjected to a current inrush of 80 amp. every operation.

To simulate field operating conditions it is important to have the switch under test close a circuit containing a cold lamp (or a bank of lamps, if necessary to make up the required value of current) every cycle, in order to produce the maximum peak which would be encountered in actual service. Since it takes approximately 55 sec. for a hot lamp to cool sufficiently to produce the maximum initial current peak, the switch would have to be in the "off" position for 55 sec. To accelerate the testing, several banks of lamps per switch are employed, so arranged that while one is energized, the others are cooling. With switch operation at the rate of 10 cycles per min., 10 banks of lamps are required to produce a cooling period of at least 55 sec. for each bank. If several switches are to be tested simultaneously, the number of lamp banks needed would be equal to 10 multiplied by number of test switches.

To produce the desired sequence of lamp selection it is necessary to synchronize the operation of the test switch with a commutating device. So as not to tie the test machine mechanically with the commutator, the synchronism is accomplished electrically with a remotely controlled selector and relays mounted on the lower portion of the cross-connecting switchboard. With this arrangement the cold lamp bank is automatically introduced into the test circuit while the switch is "off," so that circuit is prepared for switch to "close" it on the following "on" operation. The succeeding changeover to another lamp bank takes place while the switch is again in "off" position. Consequently, the relays select the lamps while no current is passing through their contacts, and therefore interrupt no current. Should the selector get out of step with the switch operating machine, the circuit is automatically broken, and the test machine is stopped.

To pass the lamp-load endurance test the switch must be capable of operating 6,000 cycles, the normal current of the lamps being equal to rated current of the switch. This test follows the 6,000 cycle resistance-load endurance test.

The heating of the lamp filament is not instantaneous. This fact, together with the reactance of the circuit, is responsible for a time-lag in attaining the maximum (peak) value of current. This is an important consideration in determining the required capacity of the power source.

The Underwriters' Laboratories, Inc., specify a generator of a capacity such that when it is connected to a lamp-load of 20 amp. normal value, the initial peak current in the lamp circuit is to be 160 amp. or 8 times normal load, and the peak is to be reached in not more than 0.0042 sec. However, when the generator is called upon to furnish current to the entire laboratory, it should be capable of delivering the necessary extra current. The total capacity required may be determined by integrating the area under a curve representing the relation between the time and the current required by all test machines during a typical cycle. Consideration should be given to the overlapping of "on" periods of switches on a test machine, and to the non-synchronous operation of all test machines, for they are usually driven by individual induction motors.

A power supply unit consisting of an a.c. motor driving 2 d.c. generators, each delivering 125 volts, is shown in Fig. 6. Provision is made at the generator switchboard to connect the generators in series to obtain a 3-wire 125/250 volt system, or to operate them in parallel for greater

current requirements. In an emergency the generator busbars may be disconnected or the motor stopped from several remote points in the laboratory.

Devices which have passed the overload and endurance tests are then subjected to a heat test, which consists of passing rated current through them and measuring the temperature rise, at the heat generating points. 30 deg.C. is the maximum permissible rise.

A thermocouple with a millivoltmeter is used for taking measurements. The current for this test is derived from a low-voltage secondary transformer, having adjustable primary taps.

The dielectric strength test is intended to check the quality of the insulating materials used, and to assure safety to the operator. It consists of a gradual application of high voltage between the insulated current-carrying parts, and also between these parts and the "grounded" portion of the device. The voltage upon reaching the maximum required value, is applied for 60 sec. The source is connected directly, without series resistance (thus assuring full potential) across the points under test. When a breakdown occurs the secondary is "shorted" causing the circuit-breaker in the transformer primary to open.

The tests described are the minimum required by the Underwriters' Laboratories, Inc. Manufacturers however, are not content with these limitations and usually set up standards which are considerably higher. This especially applies to endurance tests. While the requirement calls for 6,000 operations at rated load, the devices usually survive many times this number. Again, the specified dielectric-strength voltage which 250-volt devices are to withstand is 900. The actual breakdown voltage of many devices is almost 3 times that value.

Torque Testing Machine

There are many similar exacting requirements in the mechanical construction of wiring devices in which complete devices are subjected to various mechanical tests. An interesting machine is shown in Fig. 7 for conducting mechanical tests. The machine has a metal-bob pendulum oscillating in well-fitted ball bearings. When a torque is exerted at the shaft forming the pivot for the rod supporting the bob, the bob is deflected, and if its weight and the angular deflection are known, the reaction it offers may be calculated and recorded on the dial. The dial is graduated to read directly in in. lb. Adjustable counterweights are provided so that the machine can be put in static balance.

With this machine, it is possible to measure the grip of a screw-shell of a lamp holder to the holder. This point is important, for unless the shell is held securely, it may be pulled out while a lamp is being screwed in. The holder is mounted on the pendulum so that its center of oscillation coincides with the axis of the screw shell, and a screw plug is inserted into the shell. The plug is turned by a crank until the desired torque is produced, as indicated on the dial, and is held at this value for one minute. The pull-out torque is required to be more than 20 in. lb. at the shell.

When a pulley of a known diameter is mounted integrally with the pendulum, so that its center coincides with the center of pendulum's oscillation, and if a flexible wire with one end fastened to the pulley is placed over the periphery of the pulley, the dial will read the pull in pounds when the free end of the wire is put under tension. Thus, it is possible to measure various pull-out forces, such as force required to operate pull-chain devices, the force necessary to pull out clamped cable from a switch box, or the pull needed to disengage a plug cap from a convenience outlet. It is also easy to determine the strength of pull-cords and of various materials, as well as of different types of fastenings. Simple adapters make it convenient to receive any wiring device for twisting or pulling test. The range of the machine can be changed by either varying the length of the pendulum, or by changing the weight of the bob.

About two decades ago research was confined to a few Government and university laboratories. The work that has come out of these laboratories has been of great scientific value, but it has not always furnished answers to particular problems met in designing or in manufacturing certain products. To obtain these data the manufacturers established laboratories of their own, where industrial research for the solution of their specific engineering problems was conducted. The manufacturers of wiring devices quickly realized the necessity and the value of such work, and set up their own research laboratories.

A corner of a satisfactory electrical research laboratory is shown in Fig. 8. In the illustration one can see a Kelvin double bridge for very low resistance measurements (such as contact resistance), a Wheatstone bridge for medium resistance measurements and an Oscillograph. Additional associated devices, such as galvanometers, rheostats and ammeters can also be observed. The oscillograph is an instrument of great importance in the hands of the research engineer, for it permits the study of transient phenomena occurring during the operation of various mechanisms.

Oscillograph Film Holder

Since the phenomena to be studied are usually of very short duration, of an order of 0.001 seconds, and are not recurrent, it is impossible to observe them visually. Consequently they are recorded photographically. Furthermore, since short intervals of time are involved, the film must be run at a high speed, usually above 25 ft. per sec., to produce a scale of easily measurable magnitude. Conventional long-film cameras are not adaptable for such application, and drum-type film holders are usually employed. Ordinary drum film holders are arranged to synchronize the occurrence of the phenomenon to be photographed with the operation of the camera shutter. However, for mechanically-operated devices such as switches, it was necessary to develop the special film holder shown in Fig. 9. With it, the opening of the oscillograph shutter is synchronized with the operation of the switch under test. A typical oscillogram, showing a switch interrupting a non-inductive circuit is reproduced in Fig. 10, to indicate relatively high film speed a 60-cycle a.c. wave is also recorded. The connections of the oscillograph vibrators (V1, V2, V3) are given on the same figure.

Testing has proved to be an important factor in the manufacture, in the production quality control and in the designing of wiring devices. Long life, dependability, compactness and safety call for the utmost care in designing and in manufacture. Without research, without suitable measuring and testing equipment, the development of wiring devices would have been impeded.

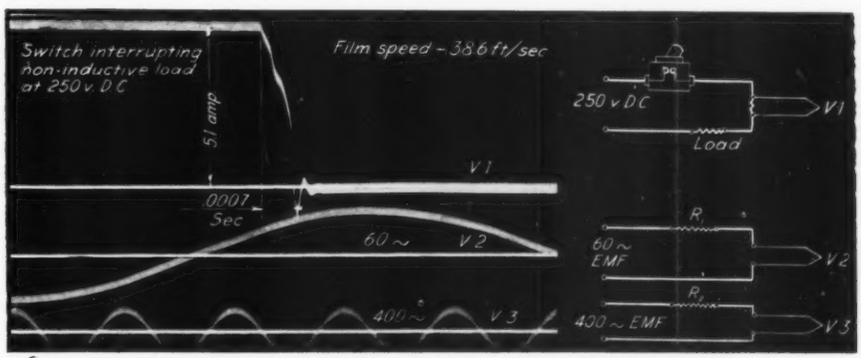


Fig. 10—Oscillogram of switch interrupting a non-inductive d.c. load. Diagrams at right show connections of oscillograph vibrators

DESIGN OF INSERTS

for Molded Plastics Parts

F. W. WARNER and R. R. MacKENZIE
Plastics Department, General Electric Company

IN DISCUSSING inserts for molded plastics it should be evident that they should be so designed as to perform their required functions most economically. The design must take into account such factors as (1) Required mechanical strength of insert in the plastic part; (2) Tolerance on position of insert; (3) Tolerance on threads in insert; (4) Tolerance on length of projecting portion of insert; (5) Required electrical characteristics of insert in the plastic part; (6) Molding material to be used; (7) Method of molding to be used; (8) Position of insert in plastic part with relation to manner of molding; (9) Position of insert in plastic part with relation to flow of material in molding; (10) Amount of molded plastic around insert; (11) General size and shape of working portion of insert; (12) Material of which insert is made; (13) Methods of manufacturing insert; (14) Operations to be performed on insert after molding; (15) Effect of insert on scrap loss during molding or assembly.

Not all of these factors, of course, apply to every insert. Inserts can be roughly classified as (1) Rod or wire inserts; (2) Inserts with male threads; (3) Inserts with female threads; (4) Spun-over type inserts; (5) Stamped or punched inserts; (6) Miscellaneous.

FIG. 1—In general these rod inserts must be used with comparatively soft or free flowing molding materials. Their use will probably be restricted to injection molded or transfer molded articles or very favorable designs in compression molded articles. Very little side flow of material under pressure can be permitted as the inserts will bend readily or even shear off. Insert (*a*) may also lift out of position due to flow of material. A hardened insert such as (*d*) may be so displaced in molding as to spring out of position when removed from the mold.

FIG. 2—In these rod inserts, (*a*) and (*b*) must be located from the projecting end and supported by the end during molding. Pressure may upset the insert to the size of hole in the mold which if slightly rough will cause scoring on withdrawal. Flash or dirt in the hole will change the projecting length or if the inserts are supported by knock-out pins the length will vary because of variation in seating of the knock-out bar. There is no general rule about length of insert imbedded in the plastic as this will depend upon the pull which the insert must stand, the molding material used, the insert material used, and the flow of material against the insert. In undercutting inserts, such as (*b*), the undercut should be quite shallow and preferably in the knurled section. The depth of groove should not ordinarily exceed the width of the groove. A half round shape of groove is quite satisfactory in most cases. In insert (*d*) the imbedded shoulders will provide anchoring against axial displacement. An insert such as (*e*) can be used in place of (*c*) or (*d*) frequently. This has the advantage that the stock used is of finished diameter. An upset insert such as (*f*) can also be used.

Where the projecting length of insert is important, or where the surface must be kept free from scoring or flash, a shouldered insert such as (*g*) or (*h*) should be used. This should be chamfered as shown, as should all inserts, and may be undercut if desired.

FIG. 3—While inserts with female threads should *preferably* extend above the molding surface, in practice this can be done on only perhaps ten per cent of them. This is desirable, of course, as it helps support the insert in position at the same time that it prevents material flowing into the threads. Insert (*c*) results in rather weak mold construction and also requires concentricity of center hole and shoulder as a pilot is ordinarily used in the threaded hole. Insert (*d*) should ordinarily have thick surrounding walls in thermosetting plastics to prevent cracking.

FIG. 4—The amount of knurling will largely be governed by the cost of knurling. The extended portion of (*a*) and (*d*) will ordinarily be received by recesses in the bottom of the die while inserts (*b*) and (*c*) will ordinarily be piloted into the top member of the die. It is general practice to mold through inserts with through holes. Holes may be retapped after molding to remove molded material, or as in (*e*), a loose threaded pin may be used on the top side to enter the top member of the mold.

FIG. 5—The holes in (*d*) and (*e*) are rather expensive to obtain and present little or no advantage over types (*a*), (*b*) and (*c*). Trouble will frequently be had with (*f*) in obtaining good anchorage as material will fill the holes and then continue to flow past, forming a flow or cleavage line of low strength.

FIG. 6—While many punched, stamped or formed inserts are used, difficulty is usually had in holding them to proper size to fit the mold. Inserts with male threads may be similar to (*h*), (*i*) or (*j*). Flat head or oval head screws can be satisfactorily used when supported as in (*h*). Round head screws used as in (*i*) are not very satisfactory as pressure on the head shortens the lead of the thread and molded material gets in the threads, necessitating a cleaning operation. Insert (*j*) is much more feasible as it eliminates both these defects.

For spun-over inserts, eyelets such as (*k*) can sometimes be used although rivets as (*l*) or screw machine inserts as (*m*) are to be preferred, (*m*) being most satisfactory on thermo-setting plastics.

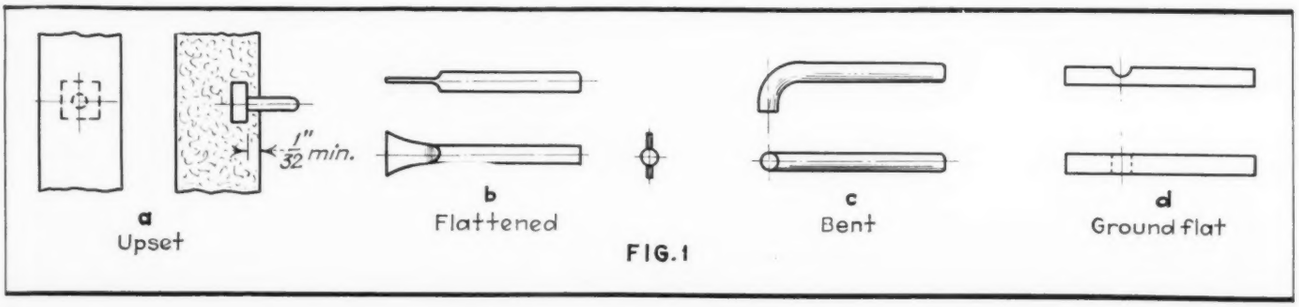
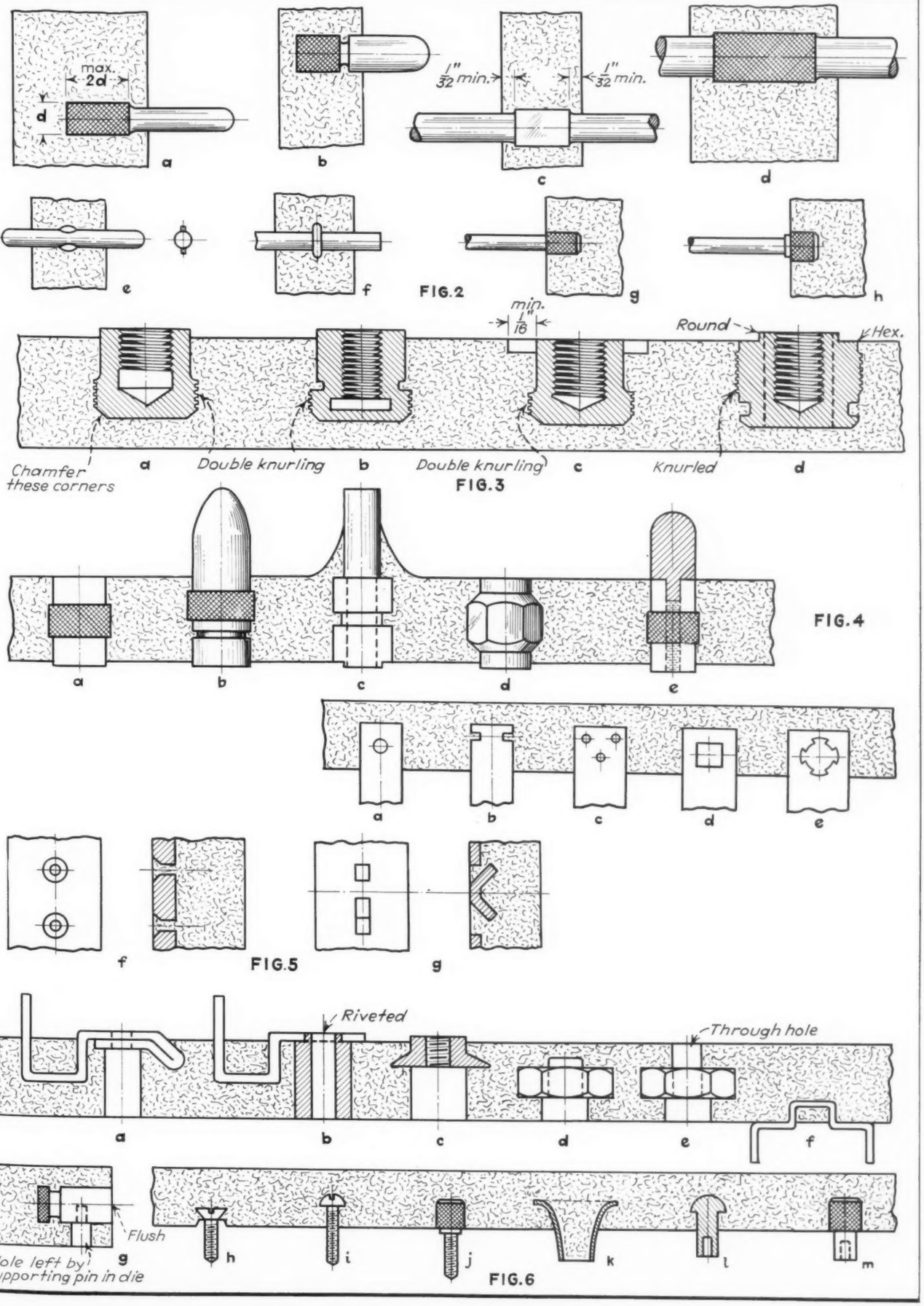


FIG. 1


max. 2d
d
a
b
1/32 min.
1/32 min.
c
d
e
f
g
h
FIG.2
min. 1/16
Round
Hex.
Chamfer these corners
a
Double knurling
b
Double knurling
c
Knurled
d
FIG.3
a
b
c
d
e
FIG.4
a
b
c
d
e
f
FIG.5
g
Riveted
Through hole
a
b
c
d
e
f
Flush
g
Hole left by supporting pin in die
h
i
j
k
l
m
FIG.6

Question and Comment

Sleeve-Bearing Wall Thickness

R. G. N. EVANS
Bunting Brass & Bronze Company

When designing a bronze sleeve bearing for a definite application, the alloy selected should have enough resistance to deformation under the imposed load regardless of its kind—shock or constant—and possess the greatest amount of non-scoring qualities. By determining the wall thickness of the bearing on that basis, the bearing can be expected to function properly and give desired life.

In the following chart are listed nineteen alloys in the order of increasing tensile strength. The chemical analyses are omitted purposely as the specification of the physicals would control the chemical analyses and founding practice needed to produce them. Specifying chemical analyses does not guarantee the maximum physicals and it is the physical characteristics alone, not the chemical content, that the engineer is concerned with. Usually, the purchasing agent unknowingly orders on the basis of chemical specifications and may or may not obtain the physicals, thus defeating the aim of the engineer. In the table, the alloys are listed also in direct order of non-scoring qualities and in reverse order for resistance to deformation.

The alloy having a Brinell hardness reading of 28 has the greatest non-scoring characteristics with zero lubrication, but it has the least resistance to deformation; while the alloy having a hardness reading of 85 has the least non-scoring characteristics but has the greatest resistance to deformation. The method used to obtain the non-scoring relations was described in the author's paper "Coefficient of Friction Is a Minor Factor in Bearing Design" in *Metal Progress*, July 1938.

The compressive limits shown in the chart were obtained in the laboratory of a prominent technical institute, using a specimen 0.994 in. in diameter and 0.850 high. For the data shown on chart Fig. 1, SAE 660 was used. It has a compressive limit of 20,000 lb. per sq. in. Six specimens, of one in. diameter, with heights of two in., one in., ½ in., ¼ in., ⅛ in., and 1/16 in. were tested.

A pressure of 31,500 lb. per sq. in. deformed the two in. specimen 0.160 in., but had no effect on the 1/16 in. specimen. Obviously the thickness of a bearing side wall or the thickness of a thrust washer is important, having a definite relation to life. Non-scoring advantages of the softer materials can be gained by definitely calculating this dimension.

Machines are designed to accomplish certain functions, and the bearings in the machine must stand up or the entire machine fails. The bearings should be designed with reference to loads, speeds,

Copper-Tin-Lead Bearing Bronzes

Brinell	*Rockwell*	*Sn-Cu Ratio*	*Order Non-Scoring*	*Tensile Strength*	*Yield Strength*	*Elongation*	*Compressive Limit*	*Order Resistance Deformation*
28	....	0.032	1	12,000	5,000	5 per cent	8,000	12
35	....	0.042	2	15,000	7,000	5 per cent	10,000	11
36	....	0.059	3	18,000	8,000	5 per cent	12,000	10
38	....	0.071	4	20,000	10,000	8 per cent	13,000	9
40	....	0.060	5	22,000	11,000	12 per cent	14,000	8
50	....	0.059	6	28,000	14,000	15 per cent	17,000	7
52	....	0.103	7	30,000	14,000	15 per cent	18,000	6
55	....	0.127	8	30,000	15,000	15 per cent	20,000	5
58	59	0.084	9	34,000	16,000	20 per cent	20,000	
60	63	0.125	10	35,000	17,000	20 per cent	21,000	4
60	63	0.120	11	35,000	17,000	15 per cent	21,000	
65	71	0.084	9A	37,000	17,500	8 per cent	22,000	
65	71	0.114	12	40,000	18,000	20 per cent	22,000	3
65	71	0.116	13	40,000	18,000	20 per cent	22,000	
65	71	0.091	14	40,000	17,000	15 per cent	22,000	
67	73	0.113	15	40,000	18,000	20 per cent	23,000	
67	73	0.124	16	40,000	18,000	20 per cent	23,000	2
75	77.5	0.133	17	40,000	18,000	12 per cent	23,000	
85	85.5	0.165	18	40,000	15,000	10 per cent	24,000	1

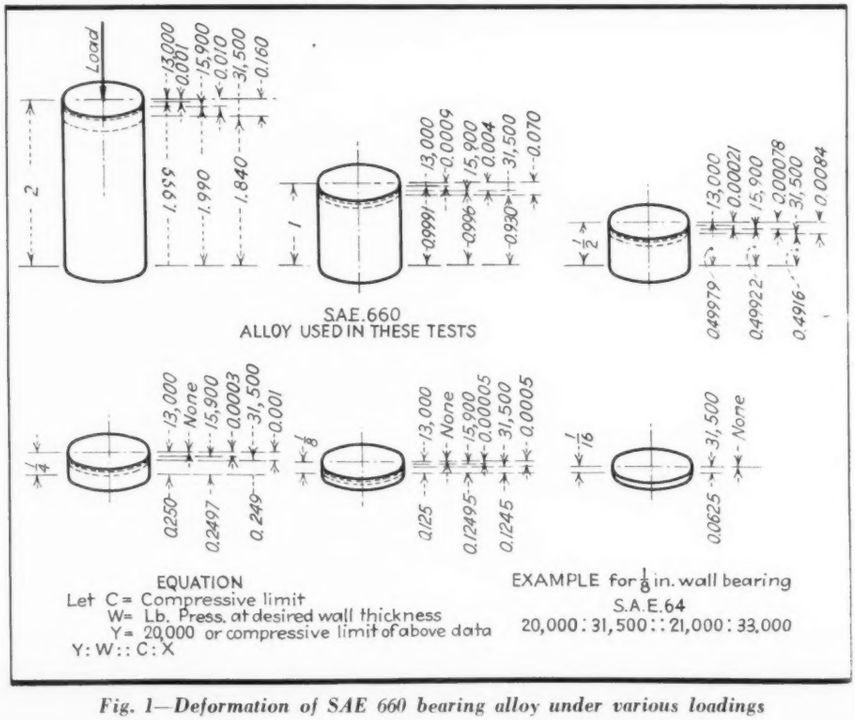


Fig. 1—Deformation of SAE 660 bearing alloy under various loadings

lubrication provisions, effect of oil leakage on product being processed, the possibility of abrasives entering the bearing, correct grooving, and seal protection if it is necessary. The wall thickness should then be based on the alloy with the greatest non-scoring qualities to avoid failure by scoring at moments of zero lubrication. The bearing should also have ample resistance to deformation for its wall thickness, to prevent hammering out of the bearing by imposed load.

In other words, the designer of sleeve bearings no longer needs to estimate. Sufficient sleeve bearing data is available to permit proper bearing design to obtain maximum life. Short life, down time, ruined product and complaints by the purchaser or his own management can be eliminated. Requests for a different type bearing, alteration of design to fit the recommendations of the engineer of the other type for boundary dimensions, protecting the bearing by closures which increases cost and does not always cure the trouble, will not be necessary.

Other type bearings are required in certain applications, but properly designed, lubricated and protected sleeve bearings will give the majority of cases satisfactory life, and will remain quieter with freedom from vibration, chatter and whipping of the lubricant at less initial cost.

Effect of Forging on Tensile Strength

To the Editor:

On page 310 of the August 1938 number of *Product Engineering*, Jay C. Reed inquired as to whether the forging process increases the tensile strength or decreases it.

In answering the question as to the effect of forging on tensile strength, there are two ways in which this property is increased. The first of these and decidedly the lesser is direct improvement through elimination of inter-crystalline voids, which may be designated as an increase in the density of the steel. The second and more important, although indirect, method by which forging increases tensile strength depends upon the fact that while higher tensile strength with its accompanying higher elastic limit is in general desirable, it is in many cases impossible to take advantage of because of dangerous brittleness experienced unless improvement of the natural properties of the metal can be effected through such means as forging. With the improvement possible by forging, it is practicable to use higher tensile strengths because superior toughness can be obtained even with the greater hardness accompanying such values.

Tensile strength as such is seldom the most important qualification of metal in engineering applications. Other qualifications of material which are of more importance, particularly in applications such as crane hooks, are: elastic limit or maximum unit stress which a material will withstand without undergoing permanent deformation, and resistance to dynamic loading such as shock loads or repeated imposition of strain. A third qualification, less inherent in the material than in the manner of fabrication, is the reliability with which parts can be produced and their soundness verified by inspection methods commonly available.

The principal advantages of forgings are primarily in superior physical forming. Plastic flow modifies cleavage planes, intercrystalline weaknesses or voids and coarse crystalline structure, which are characteristic of material as solidified from the molten state, in such a manner as to increase very markedly the toughness and consequent resistance to dynamic loading.

As a result, two distinct advantages accrue in the design and use for forgings such as crane hooks as compared with similar parts produced without plastic working. The first of these is that no increase in size beyond that indicated by service requirements is necessary to allow for undetected internal voids and other defects; the second is that adequate toughness and dynamic strength can be obtained even at high elastic limits and tensile strengths, thus permitting, for a given load, reduced sections with higher strength with the consequent advantage of lower weight and less bulk.—RAYMOND M. SEABURY
Drop Forging Association

Forced Vibrations

To the Editor:

With reference to the article by Dr. Fuchs, entitled, "Forced Vibrations," which appeared on page 256–258 of *Product Engineering* for July 1938, we wish to congratulate the author and your magazine on one of the best analyses of this complex subject which has ever come to our attention. It is, therefore, unfortunate that an error crept in, which although minor, presents quite an obstacle to easy understanding by the reader.

Quoting from the first column on page 258:

"For a fly wheel vibrating in torsion as represented in Fig. 4 (*c*), with $h = 0$, $e = 0$ and instead of c_1, the torsional stiffness C_1 in in. lb. per radian is used, . . ."

This should read:

"—instead of l^2 c_1 the torsional stiffness, . . ."

As a matter of fact, the general equation does not reduce to the fly wheel expression unless the substitution as corrected is made. This will be readily understood if it is noted that *Ca* is the torsion in Fig. 4 (*c*) while *al cl* is the torsion in Fig. 3, since the spring deflection is "*al*" hence the spring force is "*alc*" which multiplied by the lever arm "*l*" gives a "*alcl*" for the torque. Dividing the torque by the angular deflection in each case, gives *C* for the torsional stiffness in Fig. 4 (*c*), and since the angular deflection in Fig. 3 is "*a*", the torsional stiffness in Fig. 3 is *l²c*.

This was the only confusing point in the entire article so that the undersigned feels that it might be considered desirable to correct this.

—R. E. BRUCKNER
Kimble Glass Company
Vineland, N. J.

To the Editor:

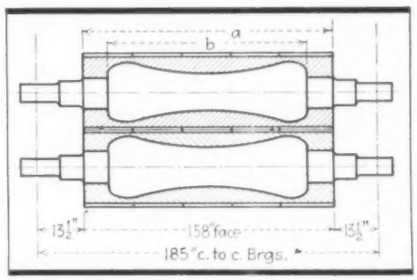
Mr. Bruckner is quite right in his correction. I am sorry to have let this slip pass in the manuscript; and I am grateful to Mr. Bruckner for pointing out the error. —H. O. FUCHS
General Motors Corporation

Designing Press Rolls

To the Editor:

I am enclosing a sketch of a press roll problem that I have been working on. This press roll is to be used on pulp; it can be described as a smoothing press roll. The pressures are very high, 1,000 lb., per in. of face. The rolls are to be crowned for a deflection of 0.003 in. and it is desirable to start with this curve and work to the proper roll construction.

Over what part of roll unit should deflection be calculated, between bearing centers, over roll face, distance "a", or between roll heads, distance "b"? What method of solving for deflection should be used for the above conditions? How should the moment of inertia vary, also where does modulus of elasticity change,

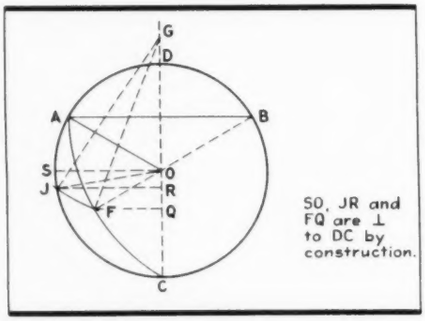


as from a cast iron roll to steel journal? What is the effect of thin, short steel sleeves about ¾ in. thick, shrunk onto the roll? What type of roll construction should be used: cast iron, truss constructed; steel shell (forging) cast iron heads; or chilled cast iron, truss constructed? —GEORGE ANDERSON
Tacoma, Washington

Dividing a Circle

To the Editor:

On page 346 of the September number of *Product Engineering* there is a method outlined for dividing a circle into nine equal parts. It can be shown in several ways that the method is incorrect. The simplest method is to try this system on a large circle, say ten



inches in diameter. An accurate drawing at this scale will show a definite discrepancy.

Another method is to calculate the sine of the angle between the line *JO* and a line drawn perpendicular to the line *DC*. The sine of this angle should be the sine of 10 deg. or 0.1736+.

The following is proof that the angle is not 10 deg. In a unit circle, radius *OA* is equal to unity, and the line *AB* is equal to $\sqrt{3}$ by construction.

The distance $OF = BF - OB$

or $OF = \sqrt{3} - 1$

The angle $FOC = 60$ deg., by construction; therefore, $FQ = OF \cos 60$ deg., and $OQ = OF \sin 60$ deg., or $FQ = \frac{1}{2}(3 - \sqrt{3}) = \frac{\sqrt{3}}{2}\left(\sqrt{3} - 1\right)$ and $OQ = \frac{1}{2}\left(\sqrt{3} - 1\right)$

The distance $FG = \sqrt{3}$ by construction

Therefore

$$GQ = \sqrt{(\sqrt{3})^2 - [\tfrac{1}{2}(3 - \sqrt{3})]^2}$$

$$= \sqrt{\frac{3}{2}\sqrt{3}} = \frac{\sqrt[4]{27}}{\sqrt{2}}$$

and $OG = GQ - OQ$

$$= \frac{\sqrt[4]{27}}{\sqrt{2}} - \tfrac{1}{2}(\sqrt{3} - 1) = 1.246 +$$

Then $(OG + OR)^2 + OS^2 = GJ^2$, and $OR^2 + OS^2 = OJ^2$; or $OG^2 + 2\,OG\,OR + OR^2 + OS^2 = 3$; and $OR^2 + OS^2 = 1$

By subtraction $OG^2 + 2\,OG\,OR = 2$ and $OR = \frac{2 - OG^2}{2\,OG}$; Therefore $OR = \frac{2 - 1.246^2}{2\,(1.246)}$ $= 0.1797 +$; And $\frac{OR}{OJ} = OR = \sin SOJ = 0.1797 +$. But sin 10 deg. $= 0.1736+$. Therefore sin $SOJ >$ sin 10 deg. and $SOJ >$ 10 deg.

—F. V. TARBELL
Erie, Pennsylvania

Correction

To the Editor:

In the article by Mr. Smith on the use of elastic models for studying stresses in welded joints, published in *Product Engineering* October 1938, there is a discrepancy between the captions and illustrations for Figs. 4 and 5 on page 401. They are evidently reversed.

—W. T. SAVAGE
Brooklyn, N. Y.

[Editor's Note—Mr. Savage is correct. Through an error in placing the cuts at the time of publication, the photographs for Figs. 4 and 5 were inadverdently reversed.]

Lead Copper Not an Alloy

To the Editor:

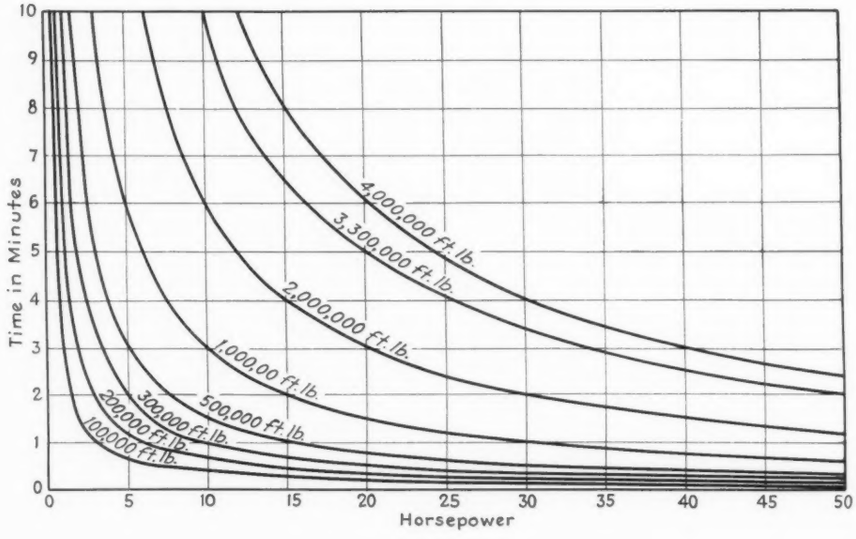
The writer wishes to correct a statement which appeared on page 414 of October *Product Engineering* in the description of the high lead bronze manufactured by the Fredericksen Company of Saginaw, Mich. The description talks of the fine distribution of lead through the copper matrix, the alloy having a hardness of 22 Brinell. Of course, the sentence is inconsistent because it speaks of a mixture being an alloy. The point I want to make is that lead never alloys with copper, in spite of the fact that the term copper-lead alloys is used indiscriminately in the technical press.

—K.A.G.
Philadelphia, Pa.

Work, Time and Horsepower

The chart shown below is useful in determining the amount of work that can be done by a given motor in a given time. It is also helpful in selecting the size of motor for a specified application.

—WILLIS G. MEYERS
Chicago, Illinois



Can You Work This One?

H. E. SMITH

This month's problem—

Send More Money

An engineering student had two bills which were overdue. Hoping that the novelty of a puzzle would take the sting out of his request for more money, he sent his father the following cryptogram, in which each different letter represents a different digit:

$$\begin{array}{r} SEND \\ MORE \\ \hline MONEY \end{array}$$

What was the amount of each bill?

Solution to last month's problem—

Animal Auction

The farmer purchased 100 animals for $100, paying $10 for each cow, $3 for each pig and 50 cents for each chicken. If X equals number of cows, Y number pigs and Z number of chickens, then

$$X + Y + Z = 100$$

$$10X + 3Y + \frac{Z}{2} = 100$$

Z must be an even number, and cannot equal 100; X must be less than 10 and Y less than 33. $X = 5$, $Y = 1$, and $Z = 94$.

News

Carnegie-Illinois Opens New Irvin Works

ALL DEPARTMENTS of the new Irvin Works of the Carnegie-Illinois Steel Corporation were formally opened on December 15 before a gathering of several hundred guests. Ground was first broken for this new plant on May 22, 1937. There are three principal divisions in the Irvin Works: the 80 in. continuous hot strip mill complete with facilities for finishing hot rolled strip and sheet; a complete cold reduced tin plate mill; and a cold reduced sheet and strip mill, with the necessary pickling, annealing and finishing facilities.

The new mill will be operated on a smokeless basis, gas being used throughout with the exception of two boilers in the powerhouse, which are arranged to burn either coke breeze or coke oven gas or a combination of both as desired on a smokeless basis.

Electric power supply comes to this mill from the transmission lines at 66,000 volts, 60 cycles. The substation includes three 3-phase 69,000-6,900 volt transformer units each having a self-cooled capacity of 25,000 kva and a forced air capacity of 33,333 kva. Large ac motors for the mill and the Monongahela River pumping station, as well as drives for auxiliary 250 volt dc motor generator sets, are supplied directly from the 6600 volt distribution system. Medium and small size ac motors, lighting transformers and miscellaneous loads are served from 6,900–460 volt auxiliary transformers.

The cold reduced tin plate division of the new plant was the first completed. Strip pickling, cold reduction equipment, and all facilities for the production of tin plate were ready for operation in March, 1938. Therefore, pending completion of the remainder of the plant, coiled strip was shipped in from the McDonald 43 in. hot strip mill, built by the corporation in 1935–36 in the Youngstown area.

Slabs for the Irvin hot strip mill are shipped in over the Union Railroad from the Edgar Thomson Works, approximately 6 miles away. To assure a steady supply of slabs to the Irvin mill, the Edgar Thomson plant has been expanded by the installation of a modern 45 in. x 80 in. reversing - universal slab mill, capable of handling ingots up to 45,000 lb. and rolling slabs up to 8 in. x 60 in. x 30 ft. long. Because of furnace limitations, the maximum length of slabs furnished to the Irvin plant is eighteen ft.

These slabs are stored in the 64,000 ton slab yard at the north end of the Irvin Works, adjacent to the 80 in. continuous hot strip mill. Slab conditioning beds with special facilities for removing surface imperfections by oxyacetylene scarfing are provided at each end of the slab yard. Three continuous zone-controlled, triple-fired slab heating furnaces utilizing coke oven gas are installed to assure an ample supply of hot slabs for rolling. Both ends of the furnace approach table are equipped with magazine feeders and each furnace is equipped with two motor operated slab pushers. A slab return conveyor is installed at the end of the mill approach table.

The Irvin Works puts the Carnegie-Illinois Steel Corporation in a position to supply either hot or cold rolled strip or sheet, from 18 in. to 77 in. in width, in practically any desired finish, as well as tin plate and tin mill black plate, for use in automobile frames, refrigerator cabinets, tin cans and other products.

Every care has been exercised to assure maximum safety throughout the entire plant and special provision has been made for the comfort and convenience of the workers. Pickling, electrolytic cleaning, and tinning lines are covered or hooded to eliminate steam or fumes.

Convenient parking areas are provided near the main entrance to the plant, and tunnels under the railroad tracks take the workers directly to the several buildings. Restaurant facilities are provided, as is also a completely equipped hospital. A 30-ft. roadway encircles the entire plant and a new road is being built to connect the plant with the state highway system. All shipping departments are provided with convenient truck loading space within the buildings, serviced by overhead cranes.

New Irvin Works of the Carnegie-Illinois Steel Corporation at Pittsburgh to process hot or cold rolled strip or sheet, tin plate and tin mill black plate. Plant was formally opened December 15, 1938

New Lightweight Stainless Steel Train

A NEW four-car unit train, diesel-electric powered, to be added to the Zephyr fleet of the Burlington Lines, is now under construction by the E. G. Budd Company of Philadelphia.

Among the new features of the train will be a self-contained power unit for each car to supply light, air conditioning and heating. This unit will be a small diesel engine direct-connected to a generator located in a sound-proof compartment beneath the car. Another innovation in this train will be a new

braking system, developed by the Budd Company, which entirely eliminates the traditional brake shoe which bears against the wheel tread. In the new method, braking effort will be applied to disks mounted between the wheels. These disks are so constructed that they act as blowers to radiate the heat generated by braking.

Indirect lighting by fluorescent illumination will be used on this train for the first time. Fluorescent lighting produces approximately twice the illumination with a given consumption of current and more closely approximates daylight than any other artificial lighting previously developed.

The ninth Zephyr will contain a newly-developed diesel engine of 1,000 hp. built in the plant of the Electro-Motive Corporation. Stainless steel, fabricated by the "shotweld" process will be used throughout in the construction.

Ohio State Offers New Welding Course

AN ENGINEERING curriculum leading to a degree in welding engineering is now being offered by Ohio State University. The course is sponsored by manufacturers in the field of electric, gas and other types of welding. Administration will be under the department of Industrial Engineering which has been presenting for a number of years the shop courses in welding required by various curricula in the engineering college. Entrance requirements are the same as for the other curricula of the college of engineering.

Perkin Medal Award

THE PERKIN MEDAL, awarded annually for valuable work in applied chemistry by the Society of Chemical Industry, will be presented this year to Dr. Walter S. Landis for his work on cyanamid, derivatives of cyanamid, fertilizers, the first commercial production of argon and contributions to the explosive industry. The selection was made by a committee representing the five chemical societies in the United States.

AmericanFoundrymen's 1939 Convention

CINCINNATI has been selected as the location for the 1939 Annual Convention of the American Foundrymen's Association, with the meeting opening Monday, May 15 and continuing through Thursday, May 18. The entire program will be devoted to technical, management and general interest sessions, shop operation courses, round table discussions and committee meetings.

Hydrogenated Resin Now in Production

THE Hercules Powder Company has announced the commercial production of hydrogenated resin. The new product, called "Staybelite" resin, retains the advantages of resin but is claimed to eliminate the tendency of resin to oxydize and become brittle and yellow with age. "Staybelite" is light in color and the color is claimed to be impervious to light. It is expected that hydrogenated resin will broaden the use of resin in paints, varnishes, lacquers, adhesives, rubber and paper; and that it can be used in other processes where resin has been indicated but was not used previously because of its tendency to deteriorate.

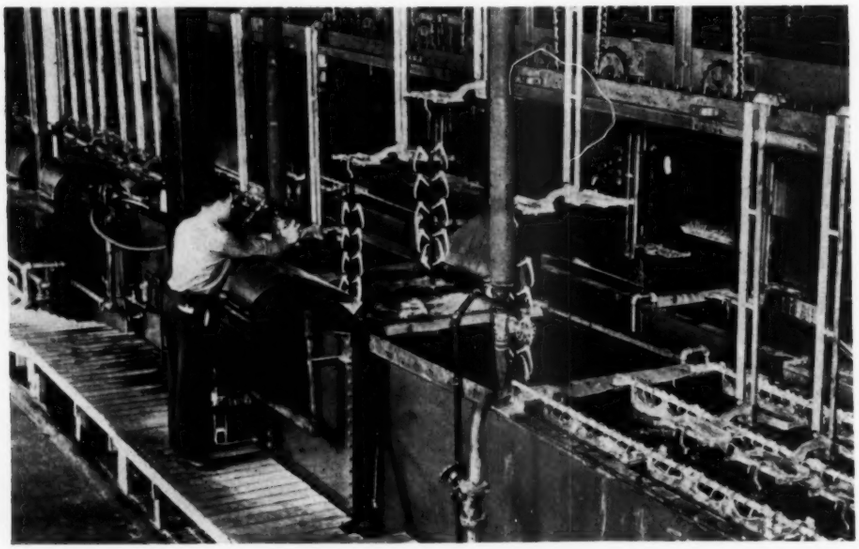
Executives Discuss Research Personnel

INDUSTRIAL research executives representing the fields of textiles, iron and steel, optical and other special instruments, soap, home appliances, and chemicals, were represented at round-table meetings of the Industrial Research Institute held at the Engineers' Club, New York, on Dec. 2–3. Robert B. Colgate, vice-president in charge of research for the Colgate-Palmolive-Peet Co., presided.

Occupying a main place in the discussions, was the subject of research laboratory personnel. The members agreed that it is as important to know and understand their personnel as it is to know the projects of their laboratories.

O. A. Pickett, of Wilmington, Del., director of the experiment station of the Hercules Powder Co., said that personnel is one of the most important jobs of the research director, and advocated that men in charge of scientific research keep close contact with staff members.

H. Earl Hoover, vice-president and chief engineer of The Hoover Co., said: "The best research men live for the job they are doing—and they should be recompensed with a high enough salary



Fully automatic in operation, 120 ft. in length, this huge nickel plating machine is one of the features of the new Ternstedt Trenton, N. J. plant of General Motors Corporation. The final finished coat is a corrosion-resistant chromium plate, applied by a new automatic chromium-plating machine 56 ft. in length. Both the nickel- and chromium-plating machines handle the work pieces by means of special automatic conveyors

MEETINGS

SOCIETY OF AUTOMOTIVE ENGINEERS—*Annual meeting and engineering display, Detroit, Mich., January 9-13, John A. C. Warner, secretary and general manager, 29 West 39th St., New York, N. Y.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—*Spring meeting, St. Charles Hotel, New Orleans, La., February 23-25, C. E. Davies, secretary, 29 West 39th St., New York, N. Y.*

AMERICAN SOCIETY OF TOOL ENGINEERS—*Annual meeting and machinery and tool progress exposition, Detroit, Mich., March 14-18, Ford R. Lamb, executive secretary, 2567 West Grand Blvd., Detroit, Mich.*

AMERICAN FOUNDRYMEN'S ASSOCIATION—*Annual convention, Cincinnati, Ohio, May 15-18, C. E. Hoyt, executive vice-president, 222 West Adams St., Chicago, Ill.*

level so they need not worry."

Maurice Holland, director of the National Research Council's Division of Engineering and Industrial Research, acting executive of the Institute, said that certain educational institutions were now making a study of women in research. He said Europe used women more extensively in research laboratory work than is the present American practice.

Dr. Lyman Bryson, of Teachers' College, Columbia University, advocated a policy of extending prestige as the reward for good scientific work in industry, and of keeping tight the connecting links between so called "pure" research, and the more practical industrial research. "Pure research," he explained, "is research in which a negative result is deemed just as important as a positive one."

Members of the Institute, which is an affiliate of the National Research Council organized in May, 1938, held periodic meetings, forums and round-table conferences each year at which problems of laboratory organization, administration and direction are discussed and common problems attacked by the co-operative method.

The objectives of the Institute are to help establish American industrial research on a more effective business basis through united effort, to pool information and experience, which will best enable each individual laboratory to raise the level of productivity, and to increase the return on invested research dollars.

Do You Know That—

GRAIN GROWTH may be faster than wear, causing dimensions to increase. This was experienced in refrigerator compressors assembled with less than 0.0001 in. clearance between the cast iron pistons and the cylinders. Grain growth caused the pistons to stick. (1)

* * *

IN ORDER to make belt markings permanent and not subject to wear, the Chicago Belting Company now brands all their double-leather belts on the inside of the belt between the two plies with permanent printing that is legible for belt life. (2)

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *We wish to emphasize that in consenting to furnish this column where in general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr. wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.*)

No. 9

QUESTION: Can a scientific principle, a natural law, a method of operation, or an idea be patented so as to protect its discoverer until such time as he has the opportunity and the funds to reduce it to practice?

ANSWER: Unfortunately, perhaps, the only protection the originator of an idea or the discoverer of a scientific principle, law of nature, or mode of operation has is to keep it to himself until he is able to apply it to something which is new and useful. Disclosure of it makes it common property and any inventor is free to use it as a basis for developments which are patentable. This may seem unfair to some, but it is in the public interest that scientific and engineering knowledge be public property and not subject to a monopoly. Suppose that each new discovery of electrical and magnetic principles had been given patent protection. It might well have taken us ten thousand years to reach our present ability to utilize large amounts of cheap electricity in the ways we now do.

The patent law therefore covers only articles of manufacture, machines, processes, combinations of matter, designs for improving the appearance of an object and certain types of plants—and these must be new and useful. Therefore the only way a discoverer of a law of nature, scientific principle, etc., can protect himself is to apply the principle in some practical way. This has been repeatedly held in decisions handed down by the courts.

Thus in one case the court said: "A principle in the abstract is a fundamental truth; an original cause; a motive; these cannot be patented, as no one can claim in either of them an exclusive right. Nor can an exclusive right exist to a new power, should one be discovered in addition to those already known. Through the agency of machinery a new steam power may be said to have been generated. But no one can appropriate this power exclusively to himself under the patent laws. The same may be said of electricity, and of any other power in nature, which is alike open to all, and may be applied to useful purposes by the use of machinery.

"In all such cases the processes used to extract, modify and concentrate natural agencies, constitute the invention. The elements of the power exist; the invention is not in discovering them, but in applying them to useful objects."

In another case the Supreme Court laid down the rules even more explicitly. It said: "He who first discovers that an element or law of nature can be made operative for production of some valuable result, some new art, or the improvement of some known art; who has devised the machinery or process to make it operative, and introduced it in a practical form to the knowledge of mankind, is a discoverer and inventor of the highest class . . .

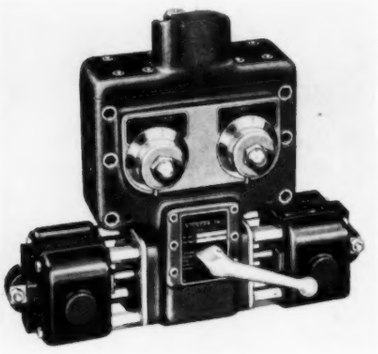
"The mere discovery of a new element, or law, or principle of nature, without any valuable application of it to the arts, is not the subject of a patent. But he who takes this new element or power, as yet useless, from the laboratory of the philosopher, and makes it the servant of man; who applies it to the perfecting of a new and useful art, or to the improvement of one already known, is the benefactor to whom the patent law tenders its protection. The devices and machines used in the exercise of it may or may not be new; yet, by the doctrine against which I contend, he cannot patent them because they were known and used before. Or, if he can, it is only in their new application and combination in perfecting the new art. In other words, he may patent the new application of the mechanical devices, but not the new application of the operative element which is the essential agent in the invention. He may patent his combination of the machinery, but not his art."

That is the law, but there are many, other than the discoverers of new scientific facts, who feel that the law is open to criticism. Dean Wigmore has this to say: "The failure of the scentific man of genius to obtain from the world any material recognition of the share due to him out of the profits which the world has made from his discoveries is a shortcoming of the law which ought, if possible, to be remedied."

New Materials and Parts

Traverse and Feed Panels

This solenoid traverse and feed panel is used for controlling rapid advance, adjustable feed rates and rapid return of a machine tool table or head. The hydraulic action within the panel is controlled by cams or dogs on the table and also by two integrally mounted solenoids. A "fine feed" rate and a "coarse feed" rate, each independently



adjustable by dials on the panel, are incorporated in the panel. Length of working stroke is adjustable by moving the control cams in the T-slot at the side of the table or head. A large variety of traverse and feed cycles can be obtained with this single portable control panel unit by means of various T-slot cams, different electrical hook-ups and the incorporation of limit switches. Panels are equipped with one integrally mounted solenoid for use where manual starting lever is convenient to the operator's position. Where starting is from a remote pushbutton station or by means of some electrical interlock action, the panel has two integrally mounted solenoids. A manually operated lever is provided for setting-up operations or for emergency stopping. Vickers, Inc., 1454 Oakman Blvd., Detroit, Mich.

Corrosion and Wear

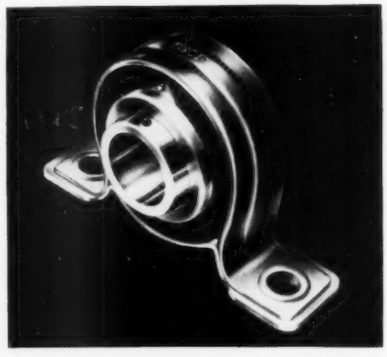
A chemical process for machine parts made of iron and steel. It consists essentially of immersing the cleaned machine parts in a boiling solution of Thermoil-Granodine for a few minutes which changes the surface into a layer of iron and manganese phosphates. This coating when oiled and used as a bearing surface, quickly becomes smoothly burnished, reducing friction to such an extent that scuffing and tearing of the metal are eliminated. Thus the metal is protected against seizure, corrosion and excessive wear. The process can be so closely controlled that tolerance limits are easily maintained. The process has been successfully applied to piston rings, pistons, valve tappets, gears, camshafts, cartridge clips, screws and similar parts. Bulletin 7-11—101 available. American Chemical Paint Co., Ambler, Pa.

Adhesive for Labels

Claimed to be capable of adhering to any surface, this Grip-Tite label paste is said to be dependable for pasting labels to practically any surface under almost any condition of temperature, atmosphere or climate. According to reported tests it has excellent adhesive power on plain, lacquered and lithographed surfaces of tin, iron, brass, lead, aluminum, stainless steel and numerous other materials. Paisley Products, Inc., 1770 Canalport Ave., Chicago, Ill.

Flexible Pillow Block

Known as "Rubberflex" pillow blocks, these new units comprise a self-locking bearing of the SKF "grip-lock" type. The bearing is inherently aligning and is encased in a pressed steel housing equipped with felt seals to exclude dirt, the housing being provided with means for lubricating the bearing. Bearing and housing are surrounded with an elastic material having specal sound-absorbing characteristics and especially treated to make it impervious to oil and grease. Its unit construction facilitates mounting. Available in ¾ and 1 in. shaft sizes. SKF Industries, Inc., Front St. & Erie Ave., Philadelphia, Pa.

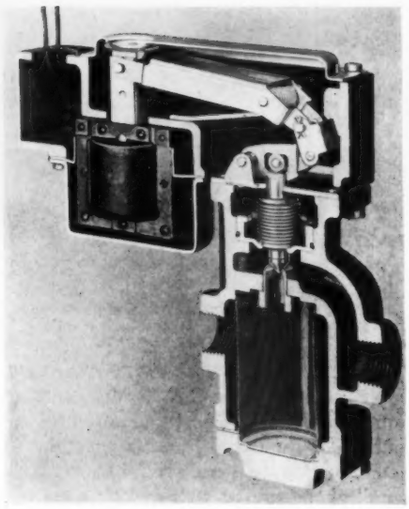


Small Power Motor

Of the permanent split capacitor type. Available with solid or resilient base to operate horizontally for floor, right or left side wall, or ceiling mounting, also to operate vertically with shaft extension up or down. Bearings are oil-tight, diamond bored and the oil wells are of ample size, felt filled and are designed for at least 1,000 hr. continuous operation per oiling. Ratings from 1/150 to 1/20 hp. and speeds of 850, 1,700 or 3,400 r.p.m. The Ohio Electric Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio.

Fabricated Z-Nickel

Now offered in various fabricated forms and different degrees of temper, Z-nickel in the unhardened or quench-annealed state is as readily worked as nickel. When heat-treated, however, at low temperatures of 890 to 930 deg. F., it attains a hardness of Rockwell C 35-45 with a strength 2½ to 4 times that of structural steel and possessing good toughness. Also it possesses a high corrosion resistance. Z-nickel is being fabricated in cold-drawn rod, wire and cold-rolled strip, in a wide range of sizes, and is available in soft, half-hard and full-hard tempers to meet intended fabrication and application requirements. Driver-Harris Co., Harrison, N. J.

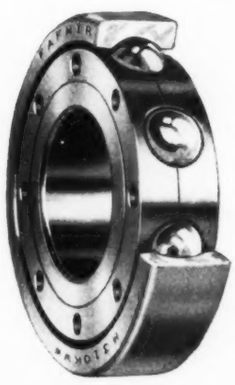


Electric Water Valve

Developed to insure tight closure against water or liquid pressure up to 150 lb. The solenoid armature is tightly seated by a spring-loaded leverage system. The long lever connected to the armature of the solenoid gives the solenoid sufficient mechanical advantage for positive opening of the valve. Valve and seat are stainless steel of file hardness and all packing is eliminated by the use of a Sylphon bellows. An unusual feature of the valve is the slot-and-roller construction which removes all angular stress from the valve stem and assures straight thrust of the cone when seating. The valve will handle any fluid, not corrosive to its working parts, at any inlet pressure up to 150 lb. Standard electrical rating is 115 volts, 60 cycle, but coils for other voltages and frequencies are available. McDonnell & Miller, Wrigley Bldg., Chicago, Ill.

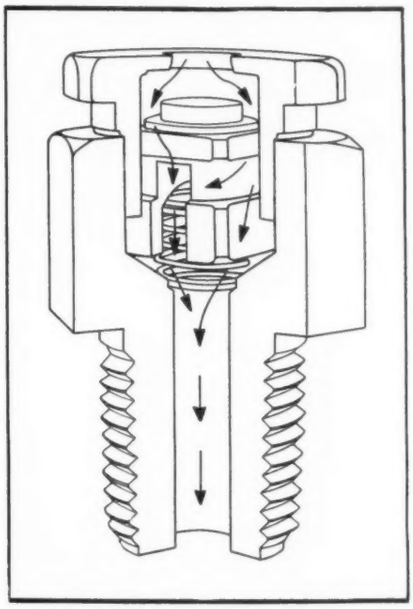
Ball Bearings for Wood-Working Machinery

Claimed to be virtually frictionless, permitting high-speed operation with comparatively small power units. Two types, WW, illustrated, with machined bronze retainer, and Duplex pairs, with composition retainer. These bearings combine large balls and deep races for high load capacity and shock resistance. Their extra-precision tolerances assure smooth running and long life. With the Duplex type, a pair may be mounted at each end of a spindle to completely eliminate radial chatter and carry a load equivalent to a much larger single bearing. The Fafnir Bearing Co., New Britain, Conn.



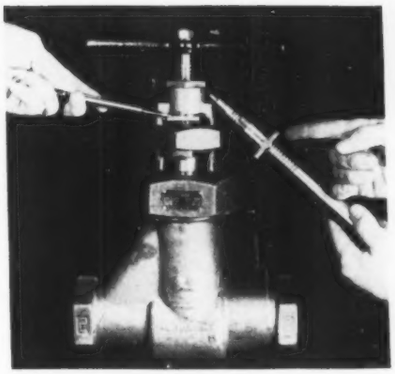
Alemite Fitting

In this new fitting the usual valve core has been replaced with one having a flat face and seat, which offers practically no impediment to the free flow of lubricant which flows unobstructed through the center of the spring and not through its compressed coils. The improved valve opens easily under slight pressure yet provides an effective and tight seal against the loss of lubricant when the pressure is removed. The bodies of the fittings are hardened to withstand rough treatment and their smooth tops eliminate the cutting or wearing of the coupling sealing washer. These fittings have been especially developed for bearings requiring large amounts of lubricant such as on tractors, presses and heavy machinery where they can save considerable time in the lubrication of the machinery. Stewart-Warner Corp., 1826 W. Diversey Parkway, Chicago, Ill.

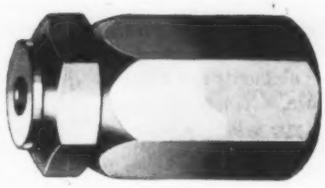


Steel Valves

Principal feature is a renewable stem bushing made of Duronze, an aluminum, copper, silicon alloy. These new bushings are claimed to meet the demand for valves that will operate satisfactorily without lubrication of the stem at full



elevated temperatures and pressures. Wear is claimed to outlast other materials, and coefficient of friction is low. Hancock Valve Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

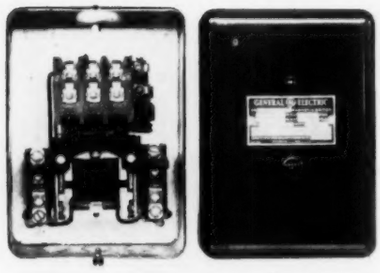


Atomizing Nozzle

An atomizing spray nozzle wherein the spray is of the hollow cone type with uniform distribution. Nozzle is of sturdy construction and accurately machined, available in male or female ¼ in. pipe connections with or without strainer. Capacities range from 1 to 14 gal. per min. at 40 lb. per sq. in. pressure. Standard stock construction is brass with stainless steel inserts. Other metals can be specified. Spraying Systems Co., 4922 W. Grand Ave., Chicago, Ill.

No. 90 Black Durex

This material has been developed for applications demanding better than ordinary moisture resistance. It shows no dye bleed in alcohol and acetone and its surface resistance to these solvents is claimed to be good. Material has the following physical properties as per A. S. T. M. specifications: specific gravity 1.33, bulk factor 2.1:1, water absorption 0.40 per cent, impact strength 0.110 ft.-lb., flexural strength 8,500 lb. per sq. in., tensile 5,000 lb. per sq. in., compressive strength 28,000 lb. per sq. in., dielectric breakdown 257 v/mil, dielectric constant 6.0, and power factor 9.6 per cent. While not equal to 75 black Durez, number 90 fills the need of a material half way between standard Durez compounds and number 75 both in quality and price. General Plastics, Inc., North Tonawanda, N. Y.

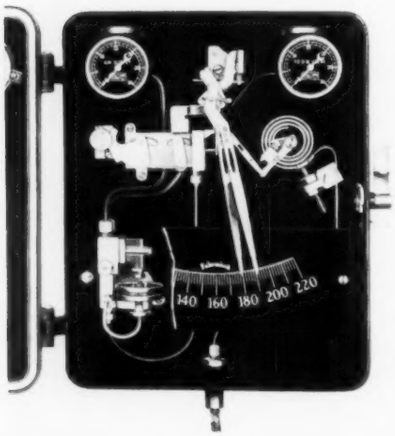


Small Motor Starter

A new a.c. magnetic switch for full-voltage motor starting, Type CR7006-D51, designed primarily to meet the requirements of machinery manufacturers for smaller control equipment for built-in mounting. Basically, the switch consists of a line contactor with interlock to provide undervoltage protection, and two isothermic temperature overload relays to protect the motor against overheating. These elements are mounted in a general-purpose sheet-steel inclosing case. The open-type switch is furnished with a rigid mounting plate to permit easy mounting on either an insulating or a conducting panel. The contactor is the direct-acting, solenoid-operated type and is entirely self-contained. General Electric Co., Schenectady, N. Y.

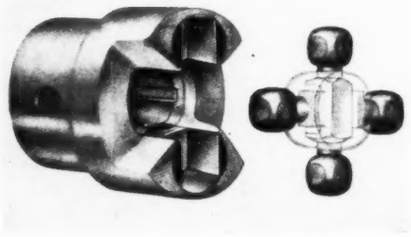
Direct Set Controllers

Designed with a strong weather-proof aluminum case finished with black enamel and chromium, these direct-set indicating controllers are available in Model 9-TIC for temperature and Model 9-PIC for pressure, and can be supplied in two types, "On-Off" and "Throttling." The on-off controller will open the diaphragm valve if the temperature is slightly below the setting point and will close the valve if the temperature rises slightly above. The throttling type is identical to the on-off design except for the flapper mechanism which provides a convenient and exacting sensitivity adjustment from hairline to 100 per cent throttling range. Bulletin 1175 describing this line of controllers is available. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.



Resilient Insulated Flexible Couplings

Coupling halves are zinc die-casting around hardened steel jaws; center section has fiber driving members molded in rubber. Neoprene furnished at slightly extra cost. These couplings will operate satisfactorily with parallel or lateral misalignment of shaft up to 0.0625 in. and angular misalignment of 10 deg. or more. Resilient center member cushions shock loads and gives complete electrical insulation, isolates vibration and makes coupling silent in operation. Available in sizes ranging from ¼ to 1¼ in. bore for maximum horsepowers at 1,800 r.p.m. ranging from ¼ to 7½. The Shallcross Co., 48th & Grays Ferry Road, Philadelphia, Pa.

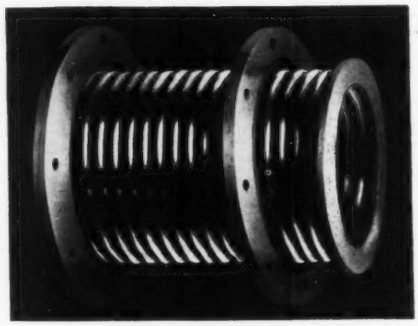


Automatic Cord Reel

Designed for extension cords on electrical appliances and various items of electric equipment, this "Cordomatic" reel maintains the exact needed cord length at all times. The cord is retrieved automatically and wound inside the metal container. It is made in a variety of sizes and designs for either external or concealed mounting. A typical Cordomatic reel 5½ in. in diam. by 2 in. wide will, depending upon the cord specification, accommodate a cord length up to 15 ft. Other sizes accommodate up to 25 ft. Such reels are available either with constant tension or with suitable braking device. Vacuum Cleaner Corp. of America, Wissahickon Ave., at Juniata St., Philadelphia, Pa.

All-Metal Exhaust Hose

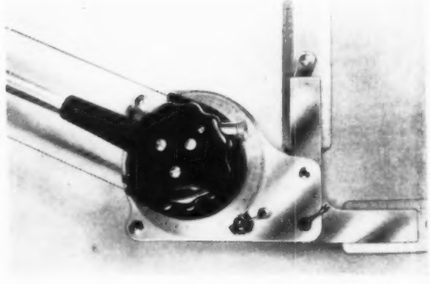
Suited for diesel engine exhaust and a variety of other industrial applications, this one-piece, corrugated, all-metal hose is said to be gas tight, seep-proof and strong yet extremely flexible. Available



in both steel and bronze, in sizes up to and including 4 in. I.D., and in continuous lengths up to 50 ft. Fabricated under the Rex-Weld "50-50" method of construction to assure minimum "working" of the tubing wall and uniform precision thickness. Chicago Metal Hose Corp., Maywood, Ill.

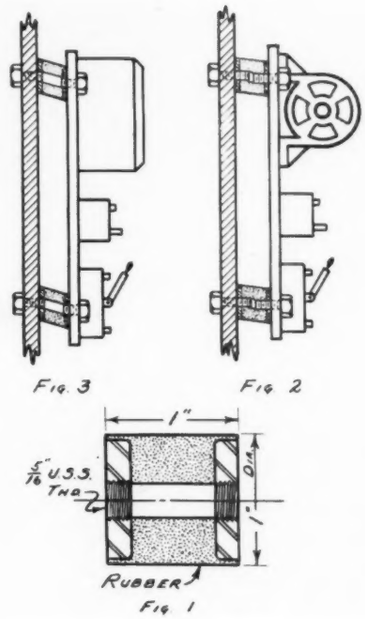
Touch Control Protractor Head

By means of a control button located on the protractor head of the new Bruning-Wallace "Touch Control" drafter the protractor head is released, allowing it to rotate freely to the desired setting. Simply lifting the thumb locks the head positively at the desired automatic index stop. A slight turn of the control button allows "free wheeling," enabling the head to rotate freely. Automatic indexing stops are provided in each of the four quadrants, corresponding to standard triangles. The double vernier reads to 5 min. The scale line-up adjustments permits the scales to be set accurately to correspond to lines previously drawn, instead of lining up the drawing to the scale. Charles Bruning Co., Inc., 100 Reade St., New York, N. Y.



Adjustable Rubber Mounting

Type 40 vibro-insulators featuring a new principle known as "adjustable deflection," whereby deflection can be regulated by the user to provide either a soft or stiff type mounting. It consists of rubber vulcanized to two parallel metal disks which are drilled and tapped for a $\frac{5}{16}$ in. U.S.S. thread. The hole extends through the entire length of the mount-



ing. Fig. 2 shows these screws penetrating nearly to the center of the vibro-insulators to form relatively stiff, small deflection mountings. Fig. 3 illustrates how the full cushioning value of these same vibro-insulators is utilized by simply attaching with short screws which penetrate only the metal disks. The Type 40 vibro-insulator is offered in only one size, 1 in. in diam. and 1 in. long, and carries a maximum load in shear of 10 lb. per mounting. Mechanical Rubber Goods Div., The B. F. Goodrich Co., Akron, Ohio.

Resilient Motor Mountings

Complete elimination of vibration and noise on motor base due to the effective use of live rubber in shear, is claimed for this rubber mounting. Available for split phase, condenser type, or repulsion-induction motor, it gives maximum absorption of vibration in the direction in which the vibration occurs, and at the same time allows for proper movement of motor in its mounting for proper alignment for drive purposes. Bulletin 1002 available. The Brown-Brockmeyer Co., Inc., Dayton, Ohio.

Motodrive Control

Providing automatic speed regulation of the Motodrive to make possible synchronization of different machines and separate sections of a single machine. On the motor (constant speed) shaft of the Motodrive is a cover plate including a lever bracket and extended lever which may be attached by chain or cable or direct to a compensating or floating roll (where properly balanced by weights), pressure regulator, moving carriage or part of machine, etc., from which indication of required speeds can be taken. Movement of the lever is transmitted to the speed changing mechanism of the Motodrive to change its speed in accordance with the indicating movement, providing the advantages in automatic con-

trol. Travel of the lever in either direction is limited by stop screws. The lever may be of any length, as required by the installation, and may be assembled in any one of four different positions. The control is available for all five sizes of Motodrive, both horizontal and vertical designs. Reeves Pulley Co., Columbus, Ind.

Hot Cathode Sterilamp

A supplement to the line of ultra-violet lamps, known as Sterilamp Type WL-791. It is a 10 in. hot cathode lamp, ½ in. diam. and designed for operation on 115 volt a.c. circuit with a current control unit similar to that used with fluorescent mazda lamps. Type WL-791 is primarily intended for use in special applications such as cabinet sterilizers and small unit air sterilizers, and for such other special purposes where either the need for or the

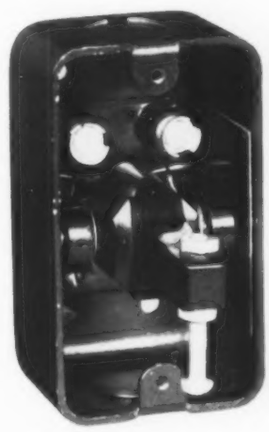
desirability of 115 volt operation is sufficient to offset the advantages of higher efficiency and flexibility inherent in the cold cathode Sterilamp line. Westinghouse Electric & Mfg. Co., Bloomfield, N. J.

Zenograph Reproduction

An inexpensive, speed method of making water-proof, smudge-proof copies, like photostats, known as Zenography. The Zenograph equipment, illustrated, is 26 in. wide, 46 in. long with shelves down, and 90 in. with shelves in place, and is claimed to make reproductions in three minutes. Cabinet has a speckled bronze-like finish with a patented pneumatic top to insure perfect contact. Reproduction Equipment Corp., 11 Broadway, New York, N. Y.

Mercury Limit Switch

Single-pole limit switch which uses a mercury-button contact mechanism to open and close the connected electrical circuit; particularly suitable for use where the force available for operation of the switch is small. The mercury-button element consists of two corrosion-resistant-metal hemispherical shells separated by a special ceramic disk with an off-center hole. When rotated in the vertical plane, the off-center hole, normally below the surface of the mercury, is raised out of the mercury, thus opening the circuit between the metal shells. Because of the tendency of the mercury to cohere, and its lack of adhesion to the insulating disk, a positive, quick break is assured. Switch must be mounted in vertical position. General Electric Co., Schenectady, N. Y.



Manufacturers' Publications

BALL BEARINGS—New Departure, Division General Motors Corp., Bristol, Conn. Booklet R-6. The 1939 edition of their ball bearing interchangeability tables presented in booklet form.

BRAZING—Handy & Harman, 82 Fulton St., New York, N. Y. Bulletin 11, loose-leaf sheet, 8½x11 in. Details on brazing cemented carbide tool tips with Easy-Flo No. 3 brazing alloy.

CONVEYORS—Chain Belt Co., 1600 W. Bruce St., Milwaukee, Wis. Bulletin 332, 6 pages, 8½x11 in. Illustrates the use and design of Rex apron conveyors, and also includes detailed engineering information concerning the use of these conveyors.

DILECTO—Continental-Diamond Fibre Co., Newark, Del. Booklet, 46 pages, 8½x11 in. Complete details, numerous illustrations and tabular data on their laminated phenolic material, Dilecto, giving properties, manufacture and uses.

DUREZ MOLDING MATERIALS—General Plastics, Inc., North Tonawanda, N. Y. Booklet, 28 pages, 5¾x9 in. Listing about 75 phenolic resin molding materials together with their physical properties. Additional pages include molding data, design data and a tabulation of other Durez products.

DURONZE III—Bridgeport Brass Co., Bridgeport, Conn. Technical Bulletin, 12 pages 8½x11 in. Details on Duronze III, a high-strength, silicon aluminum bronze, including tables of physical properties, hardness sizes, corrosion resistance, forms in which the material is available and its applications.

ELECTRICAL SHEET STEEL—The American Rolling Mill Co., Middletown, Ohio. Booklet, 32 pages. Describes various electrical sheet steel grades manufactured by the company, gives a brief account of the development of special electrical steel grades to meet the different demands of the electrical industry, and points out the advantages of ductility, flatness and other properties.

FLEXIBLE METAL TUBING—Flexible Metal Hose & Tubing Institute, 150 Broadway, New York, N. Y. "The Fact Book of Flexible Metal Hose and Tubing," 20 pages, 6x9 in. Setting forth the engineering achievements in the development of flexible metal hose and tubing, illustrating and describing the principal types and forms and their applications.

FORGINGS—Kropp Forge Co., 5401 W. Roosevelt Rd., Chicago, Ill. Folder 8½x11 in. Describing the facilities of their new machine shop and equipment for rough and finished machining of forgings up to 15 tons or more in weight.

GALVANNEALED SHEETS — Republic Steel Corp., Cleveland, Ohio. "Why Should I Use Republic Galvannealed Sheets?" Bulletin ADV-312, 12 pages, 8½x11 in. Including details on the advantages of Galvannealed sheets, corrosion resistance, forming, uniformity, coating, uses, grades and finishes, chart on gages and sizes and table of extras for widths and lengths. Many application pictures are included.

HASTELLOY ALLOYS—Haynes Stellite Co., Kokomo, Ind. "Hastelloy Alloys—Price List," 8 pages, 8½x11 in. Contains information on sizes, weights, limits and prices of Hastelloy alloy castings, hot rolled sheets and plates, and bar stock.

"K" MONEL—Development and Research Div., The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Revised Bulletin T-8, 16 pages, 8½x11 in. Containing the latest available information on the properties and useful applications of "K" Monel.

LIGHT REFLECTORS—Westinghouse Electric & Mfg. Co., Lighting Div., Cleveland, Ohio. Catalog Section 61-153, 4 pages, 8½x11 in. Describing their new "Locklite" reflectors and hoods, including tables covering styles, wattage, size, weight, and foot candle illumination for various mounting heights, spacings and different lamp wattages.

MAGALLOY—Magnesium Fabricators Div., Bohn Aluminum and Brass Corp., Adrian, Mich. Booklet, spiral bound, 16 pages, 8½x11 in. Following a well-illustrated section devoted to details concerning Magalloy castings, a data section is presented covering specifications of special and standard magnesium alloy, physical and mechanical properties of Magalloy with general information on qualities of various alloys.

METAL MOLDINGS AND STAMPINGS—Zenite Metal Corp., Indianapolis, Ind. Catalog, 46 pages, 11x8½ in. Line drawings are given showing the various sizes and shapes of metal moldings that this company can supply without revision of tools. More than 360 special shapes are shown in addition to complete parts such as rings, end forms, grilles and innumerable special stampings.

"MOLDED COLOR"—Plaskon Co., Inc., 2112-24 Sylvan Ave., Toledo, Ohio. Spiral bound booklet, 24 pages, 4x6 in. Summarizing the history and progress of Plaskon. Illustrations covering the more outstanding applications of Plaskon in various fields are presented to show the constantly increasing number of uses to which this material may be put and the part it has played in the remodeling of many industrial and domestic articles.

MOTORS—Sterling Electric Motors, Inc., Telegraph Road at Atlantic Blvd., Los Angeles, Calif. Two descriptive bulletins, No. 146 covering their Slo-Speed motors and their applications, and No. 148 covering the Sterling pipe ventilated motor and its applications.

NAME PLATES—Fox Co., Cincinnati, Ohio. Showing some of the name plates, escutcheons and decorative metal products produced by the company.

PARKERIZING—Parker Rust-Proof Co., Detroit, Mich. "Parkerizing—Rust Prevention for Iron and Steel," 24 pages, 8¾x11½ in. Complete details concerning Parkerizing presented in an interesting and informative manner.

POWER TRANSMISSION EQUIPMENT—Ramsey Chain Co., Inc., Albany, N. Y. Catalog 638, 40 pages, 6¼x9¼ in. Description and explanation of operation of Ramsey silent chains, tables of design data with particular emphasis on high speeds of typical installations.

POWER TRANSMISSION—Palmer-Bee Co., Detroit, Mich. Booklet, 48 pages. Illustrating their manufacturing facilities and many of their products and installations. The purpose of this book is to acquaint industry with their line of power transmission and materials handling machinery and fabricated steel.

RECORDING INSTRUMENTS—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. Bulletin 1178, 12 pages, 8½x11 in. Announcing a new line of "9" recorders and recorder-controllers, with a full-size 9-in. chart having a $3\frac{5}{16}$ in. pen travel.

SCREW CONVEYORS—Chain Belt Co., 1600 W. Bruce St., Milwaukee, Wis. Catalog 334, 64 pages, 7¾x10½ in. Descriptive details concerning their screw conveyor line, including screw conveyor parts and elevator buckets. Covers screw conveyor installations, selection of screw conveyors, capacity charts, specifications, etc.

SCREWS AND FASTENINGS—Parker-Kalon Corp., 200 Varick St., New York, N. Y. Spiral-bound Catalog-Data Book, 68 pages, 8¾x11¼ in. Describing the line of Parker-Kalon fastening devices. The main feature of this booklet is the wealth of engineering data contained, including complete tables of recommended hole sizes in the various types of self-tapping and drive screws, and tables of detailed dimensions of these screws. It also covers screw nails, masonry nails, wing nuts, cap nuts, socket screws, Phillips recessed head screws, and miscellaneous products manufactured by the company such as damper controls and file handles.

SHEAVES — Texrope Div., Allis-Chalmers Mfg. Co., Milwaukee, Wis. Leaflet 2333 on their 2-3-4 adjustable single groove combination V-belt sheaves.

SPEED REDUCERS—Janette Mfg. Co., 556-558 W. Monroe St., Chicago, Ill., Bulletin 22-7, 4 pages, 8½x11 in. Illustrating their line of motorized speed reducers for 1/50 to 7½ hp.

STEEL—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. Condensed Steel Stock List and Data Book, 15 pages, 4½x8½ in. Containing an explanation of the change in steel classifications and extras, general data tables for steel users, a condensed summary of products available from Ryerson stocks, and an article on the story behind Ryerson Steel-Service.

WELDING—The Lincoln Electric Co., 12818 Coit Road, Cleveland, Ohio. Bulletin 401-A, "Arc Welding Electrodes and Accessories," 36 pages, 8½x11 in. Details on the procedures for producing all types of welds in mild steel for welding on metals used to any extent industrially and for applying surfacing metals to meet any type of wear-action in service.

Network Nomogram Construction

CARL P. NACHOD
Nachod & United States Signal Company

TO CONSTRUCT this somewhat unusual type of nomogram in which a single secant solves an equation of four variables, consider a formula for stresses in a rotating disk, a nomogram for which, by O. E. Brown, appeared in *Product Engineering*, page 439, November 1935. We are interested, however, in only part of this formula, that is,

$$Q = (3 + p)\, R^2 + (1 - p)\, r^2$$

which will be constructed. No reference to the above article is necessary for the understanding of this construction.

The equation contains four variables, Q, p, R and r. If p is considered a constant, and equal to 0.2, then

$$Q = 3.2\, R^2 + 0.8\, r^2$$

This formula may be constructed as a three-parallel-line nomogram. This chart is to be such that the position of only one of the scales, that for r, will change for each value of p. The limits selected for p are from 0.2 to 0.5, while R and r are to be shown up to 10 and 7, respectively.

Let $x = m_1 (3 + p)\, R^2$

be the scale equation for R, shown at the top, and to suit the sheet, let $x = 0.08\, R^2$; then

$$0.08 = m_1 (3 + p) \text{ or } m_1 = \frac{0.08}{3 + p}$$

Similarly for the bottom scale r, let $y = m_2\ (1-p)\ r^2$, and assume $y = 0.08\, r^2$; then

$$0.08 = m_2 (1 - p) \text{ or } m_2 = \frac{0.08}{1 - p}$$

In this 0.08 is the scalar modulus for all the multiple r scales, and m_1 and m_2 are proportional to the spacing of the upper and lower scales from the middle scale. Therefore, from the above, the ratio

$$\frac{m_2}{m_1} = \frac{3 + p}{1 - p}$$

By this it can be seen that, if the scalar modulus 0.08 of both outer scales is the same, the ratio $\frac{m_2}{m_1}$ of the spacing moduli is independent of it and equal to the ratio of the coefficients of the two variables R and r. If, however, the scalar moduli are M_1 and M_2, respectively, instead of both being 0.08, then

$$\frac{m_2}{m_1} = \frac{M_2}{M_1}\,\frac{(3 + p)}{(1 - p)}$$

Also let $z = m_3 Q$ be the scale equation for Q. Since

$$m_3 = \frac{m_1\ \ m_2}{m_1 + m_2}$$

by substitution

$$m_3 = \frac{0.08}{(1 - p) + (3 + p)} = \frac{0.08}{4} = 0.02$$

This means that m_3, the modulus of Q, is independent of the value of p, and therefore Q carries but a single scale, which may be graduated. This is not general and results only because of the particular form of the coefficients of R and r. In Mr. Brown's nomogram, Q was an ungraduated turning scale, and could represent multiple scales, should m_3 have been a function of p. It was also convenient for him to have the zero points of the three scales R, Q and r on an inclined line as shown.

Substituting $p = 0.2$ in $\frac{m_2}{m_1} = \frac{3 + p}{1 - p}$

there results

$$\frac{m_2}{m_1} = \frac{3.2}{0.8} = 4, \text{ or } m_2 = 4\, m_1$$

Assume 1.2 in. as spacing proportional to m_1. Then $4 \times 1.2 = 4.8$ in. for m_2 spacing.

We may now construct the nomogram with these scale spacings, and graduate each scale with its scale equation. Assume $p = 0.5$ as the other limit, whence

$$\frac{m_2}{m_1} = \frac{3.5}{0.5} = 7$$

Then $7 \times 1.2 = 8.4$ in. spacing for the bottom r scale. Since all the r scales have the same modulus 0.08, inclined parallel lines can be drawn through the graduations of R or r. The equation for the spacing of the r scales is

$$y_1 = \frac{(3 + p)}{(1 - p)} \times 1.2$$

which can be plotted to get the intermediate values, thus completing the parallelogram at the base of the chart. The secant cutting three scales shows, for $p = 0.3$, $r = 2$, $R = 6$, $Q = 122$.

The scales for y_1, and for R or r may also be plotted by means of the two construction curves shown, which are smooth curves drawn through a few points. From the coordinates of these curves intermediate values may be obtained without calculation. The coordinates of a point in each curve are shown by dotted lines. The equation of the left curve is

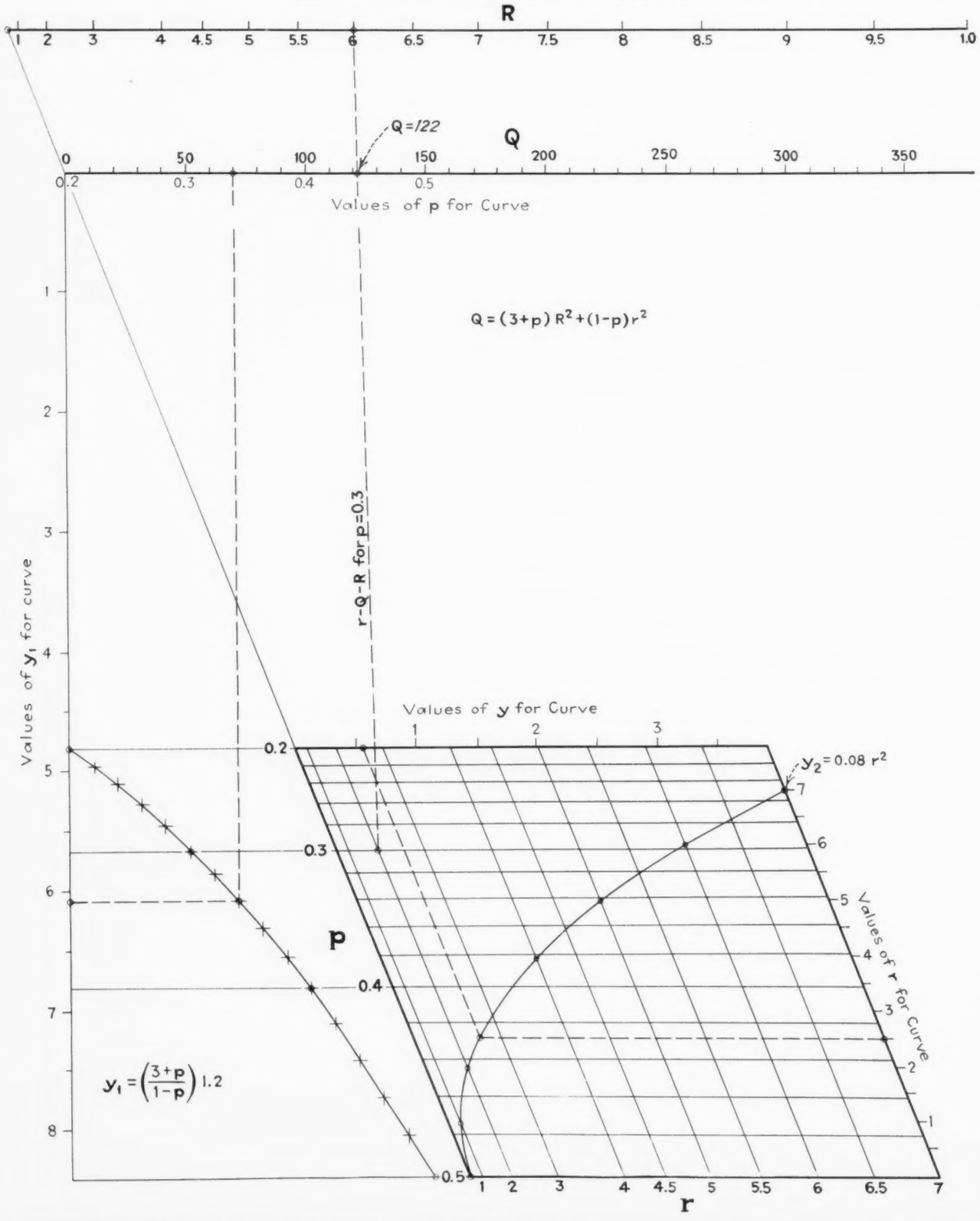
$$y_1 = \frac{(3 + p)}{(1 - p)} \times 1.2$$

Similarly, intermediate graduations on the square scale for R or r may be found from the right hand curve $y_2 = 0.08\, r^2$. The actual working chart should contain only the two graduated scales and the parallelogram network which are shown in heavy lines.

THE NETWORK NOMOGRAPHIC CHART IS SHOWN ON THE FOLLOWING PAGE

Network Nomogram Construction

SEE PRECEDING PAGE FOR EXPLANATORY TEXT



PRODUCT ENGINEERING ✦ REFERENCE BOOK SHEET